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# A DESIGN AND IMPLEMENTATION PLAN FOR A KEYPUNCH UNIT MANAGEMENT SYSTEM INCORPORATING A VARIABLE INCENTIVE WAGE RATE BASED ON INDIVIDUAL PRODUCTIVITY

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Naval Postgraduate School
Monterey, California

December 1972

# NAVAL POSTGRADUATE SCHOOL
## Monterey, California

# THESIS

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KEYPUNCH UNIT MANAGEMENT SYSTEM
INCORPORATING A VARIABLE INCENTIVE WAGE
RATE BASED ON INDIVIDUAL PRODUCTIVITY

by

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13. ABSTRACT

This thesis offers a method to reduce keypunch costs by increasing the marginal physical product of keypunch labor and machinery. The marginal physical product of labor is increased through: (1) job enrichment, meaningful employee counselling, and motivational techniques; (2) an incentive plan that rewards productive employees with higher wages or more leisure hours that is based on a Procedure Time Model which is mathematically predetermined, but adjusted based on actual production; and (3) workspace environmental improvements designed to prevent working conditions from inhibiting the motivational and technological changes. The marginal physical product of machinery is increased through matching workload requirements to various hardware configurations with detailed emphasis on keydisk hardware specifications and operational experiences. The thesis includes the procedures and computer programs necessary for implementation and the production reports and attitude questionnaires necessary to measure the degree to which implementation has been successful.

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| 3. PERSONNEL MANAGEMENT | | | | | | |
| 4. PARTICIPATIVE MANAGEMENT | | | | | | |
| 5. SALARY ADMINISTRATION | | | | | | |
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A Design and Implementation Plan for a Keypunch Unit

Management System Incorporating a Variable Incentive Wage

Rate Based on Individual Productivity

by

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Submitted in partial fulfillment of the
requirements for the degree of


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# ABSTRACT

This thesis offers a method to reduce keypunch costs by
increasing the marginal physical product of keypunch labor and
machinery.  The marginal physical product of labor is increased
through:  (1) job enrichment, meaningful employee counselling,
and motivational techniques, (2) an incentive plan that
rewards productive employees with higher wages or more leisure
hours that is based on a Procedure Time Model which is
mathematically predetermined, but adjusted based on actual
production, and (3) workspace environmental improvements
designed to prevent working conditions from inhibiting the
motivational and technological changes.  The marginal physical
product of machinery is increased through matching workload
requirements to various hardware configurations with detailed
emphasis on keydisk hardware specifications and operational
experiences.  The thesis includes the procedures and computer
programs necessary for implementation and the production
reports and attitude questionnaires necessary to measure the
degree to which implementation has been successful.

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## ACKNOWLEDGEMENT

Acknowledgement is made to Commander John M. Briggs,
Supply Corps, United States Navy, who gave me the original
idea for this thesis and who, as the Director of Data
Processing at the Naval Supply Center at Long Beach, gave
me the use of his installation to formulate my initial
hypotheses.

# I.  INTRODUCTION

If each unit of keypunch labor and machinery were more
productive, it would then be possible to maintain the current
level of output with fewer units of input.  Fewer units of
input, assuming wages are constant, would result in lower
total cost.  In terms of microeconomics, the additional out-
put generated by an additional unit of input, say labor, is
known as the marginal physical pr'  .· of labor.  Likewise,
the cost of producing another unit of output is defined as
marginal cost.  If the marginal physical product of labor
increases due to increases in productivity, ·he marginal
cost is reduced since,

$$\text{Marginal Cost} = \frac{\text{Price Per Unit of Labor}}{\text{Marginal Physical Product of Labor}}.$$

Changes in marginal physical product of labor may be
accompanied by an increase in the price per unit of labor
as the worker makes a claim on the cost reduction he has
made possible.  If the increase in price per unit of labor
is proportionately less than the increase in the marginal
physical product of labor, some cost reduction will be
realized.  At this point the producer is faced with two
alternatives.  He can either increase output while main-
taining the same total cost or he can produce the same
output at a lower total cost.  In this thesis the assumption

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will be that the data processing manager is faced with a
fixed workload and will select to produce the same output
at a lower total cost.

The goal of this thesis is to demonstrate a method to
lower total keypunch costs through increases in the marginal
physical product of labor and machinery. This goal will be
achieved through improvements in machine performance, work-
space environmental changes (lighting, color, etc.),
information for employee performance counselling, and an
incentive pay plan that financially rewards productive
employees. A premise of this thesis is that the benefits
resulting from these changes will more than offset the cost
of their implementation and use. The chapters that follow
will discuss each of the above recommended changes in re-
lation to productivity, discuss implementation where
applicable, and, for labor and machinery, project antic-
ipated costs.

Chapter II contains a discussion of the dollar magnitude
of keypunch in relation to the overall data processing
operation, the range in keypunch installation size, and out-
lines the data processing organization and job tasks upon
which this thesis is based.

Chapter III offers a discussion of the physical environ-
ment of the workspace. All facets of the workspace are
treated in general as stimulus inputs to the senses of the
keypunch operator. This combined stimulus input is discussed
in the context of arousal theory. Additionally, the effect

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of the physical workspace on the worker's motivation to
work is discussed in the context of Herzberg's motivation-
hygiene theory. Chapter III concludes with specific findings
in regard to color, lighting, noise, and music.

Chapter IV consists of a literature review of worker
psychology and motivation. It provides a discussion of the
worker as an individual and as a member of a work group.
Using an excellent survey of available research by Opsahl
and Dunnette (1966), the strength of money as a motivator
is discussed as a necessary prelude to implementation of an
incentive plan. Granting time off from work as an alternative
to a financial reward is also discussed. In conclusion,
Chapter IV outlines what others have done to encourage in-
creases in worker productivity. This discussion includes
most recognized formal plans, a look at a keypunch incentive
plan in use at the Navy's Ships Parts Control Center,
Mechanicsburg, Pennsylvania, and a summary of a few recent
private industry attempts to boost productivity through "job
enrichment."

Chapter V contains survey questionnaires designed to
measure supervisor and employee "attitude" or "morale"
before and after implementation of the recommendations of
this thesis. The results of these questionnaires will be
offered, in addition to actual labor and machinery reductions,
as an indication of the degree to which the goal of this
thesis has been achieved.

Chapter VI contains the proposed incentive pay plan. The plan includes a definition of all terms, a discussion of the implementation procedures, input requirements, report formats, time model and employee productivity calculations, and information useful in employee counselling. An optional sub-system of the proposed incentive plan which is designed to provide all necessary keypunch production data input to the Management Utilization and Control Standards Program, or MUACS, is also discussed.

Chapter VII contains a discussion of four keyboard data entry systems: (1) card punch and card verifier, (2) buffered card punch/verifier, (3) key-to-non-compatible and key-to-compatible computer tape, and (4) key-to-disk or drum. The card punch/card verifers and buffered punch/ verifiers are treated as minor evolutionary steps since inception of the first machines in the 1890's. Key-to-tape has also been used for many years and its characteristics well documented.[1] Key-to-disk or drum, however, is new and relatively unknown. The main purpose of Chapter VII is to investigate and report on the current level of knowledge and experience regarding key-to-disk or drum systems in order to provide assistance and direction in future selection/procurement actions. The first section of

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[1] See EDP ANALYZER, Vol. 9, No. 9, September 1971 and DATAMATION, June 1970.

Chapter VII provides a detailed listing of general and specific hardware and software requirements to use in comparisons of different machines.  The second section of Chapter VII reviews what actions the Navy has taken to install, test, and use key-to-disk or drum equipment.  This review includes a condensation of the test of Key Edit Hardware at the Naval Supply Center, Newport, Rhode Island.  The last section reviews the experiences of several civilian firms in installing and converting to key-to-disk or drum hardware.

Chapter VIII contains a discussion of the costs of the four different hardware configurations in comparison with their output potential.  In addition, Chapter VIII attempts to project the cost of the proposed incentive plan in terms of the probability of an individual operator exceeding the average productivity level of the installation and receiving an incentive reward.

Chapter IX, the conclusion, contains a summary of the thesis recommendations and a discussion of the Civil Service regulations that provide the environment in which the thesis will be required to function.  The conclusion is followed by an Appendix that contains the system flowchart, record and file formats, and the necessary computer programs,

Pay plans where employees receive variable wages based on productivity are by their very nature susceptible to cheating and complaints of favoritism.  The data processing

manager installing this or any wage incentives system should
consider these problems since they will most likely require
his close attention.  Additionally, data processing manage-
ment should be wary of giving rise to employee expectations
that exceed management's willingness to provide.  Charles
Schulz has perhaps said this best when:



but,



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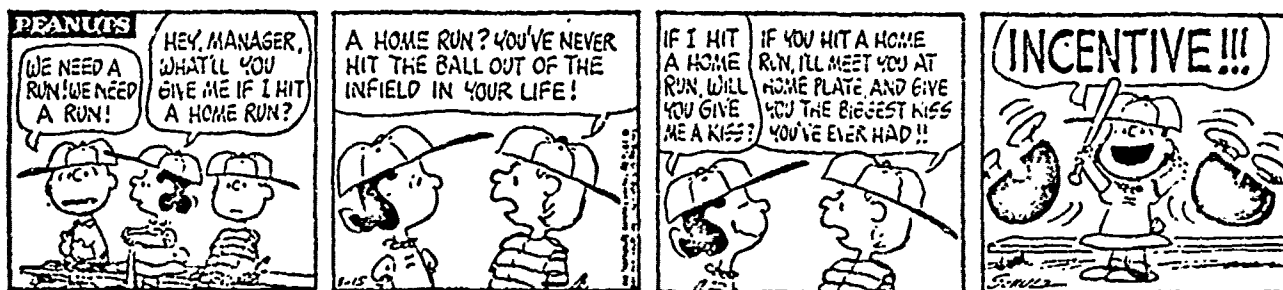
## II. BACKGROUND INFORMATION

The exact number of keypunches and verifiers in use in the United States is unknown, primarily because IBM does not disclose the number of their devices in use. Estimates range from a little over one-half million to one million machines.[2] Of the total dollar shipments of data entry equipment in 1969, Stender (1970) reports that 62% were key-punch type machines, with 46% of these being conventional keypunches, 14% data entry units (keyboard type), and 2% paper tape, a sub-species that will not be considered in this thesis. Concerning the size of installations, Stender (1970) estimates that 30,000 installations have one to five machines, 10,000 installations have six to twelve machines, 6,500 installations have 13 to 50 machines, and 1,700 installations have over 51 machines. A 1970 analysis of budget data by the Diebold Research Program estimates that at least 18% of direct data processing costs are due to data entry operations and that costs are rising at a rate of 5% per year. Personnel costs account for 80% to 90% of the data entry costs.[3]

The keypunch operator is normally organizationally sur-mounted by many levels of management, each requiring

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[2]EDP ANALYZER, Vol. 9, No. 9, September 1971, p. 7.

[3]Ibid.

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information on her performance.[4] The following is a brief outline of the data processing organization and job tasks upon which this thesis is based. Since this thesis will neither analyze alternative organization structures of data processing departments nor analyze the influence of data processing on the total organization's performance, no implication should be made that the following represents the optimal organization or assignment of job tasks.

The Keypunch Operator's prime function is to operate a machine which creates or verifies input records for submission to a mechanized process. The machines may consist of card punching and verifying machines, standard or buffered, or data entry units that utilize disk, drum, or magnetic tape storage.

The Keypunch Unit Supervisor directs the activities of the operators by preparing economic batch sizes, equitably distributing the workload, performing the administrative functions related to labor distribution, reporting employee non-productive time, and, most important, counselling each operator on her performance. The supervisor also performs the management analysis function at the individual job level to maintain the accuracy of the proposed incentive pay system.

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[4]In this thesis the keypunch operator is referred to as "she" since most keypunch operators are female. No intention is implied to restrict women to keypunching or to classify the work in terms of sex.

The supervisor is assisted in this effort by periodic production reports that will be discussed in detail in Chapter VI.

The Head of the Operations Branch is concerned with maximizing the effectiveness of the keypunch unit in the production of technically accurate input records subject to personnel ceiling point, hardware, and budget constraints. The branch head monitors the productivity of the keypunch operation via periodic production reports, and together with the Keypunch Unit Supervisor, will make recommendations on the type of hardware and the proper personnel/machine mix that should be utilized by the installation.

The Director of Data Processing is responsible for managing the data processing installation, maintaining good working relationships with the other departments of the command, and ensuring that achieving data processing's goals occurs simultaneously with achieving the command's goals. The Director's primary goal is to maximize the effectiveness of the installation subject to the budget constraints dictated by higher authority. For keypunch operations, production effectiveness indicators in personnel performance and hardware utilization as described in Chapter VI provide the necessary measurements.

## III. THE WORKSPACE

The keypunch operator works in a surrounding physical environment that provides a stimulating input to the various senses of touch, sight, hearing, and smell. When coupled with stimuli from non-physical sources such as anxiety, emotional strain, the resultant arousal level may create a stimulus overload that results in degrading job performance.

Wallace (1971) reports that as a person's arousal or alertness level increases his level of performance increases, but by successively smaller amounts until a maximum is reached. Beyond this point increases in arousal will cause decreases in performance. It is in this area that a stimulus overload exists.

Broadbent (1958) has proposed a single-channel hypothesis as a model to describe human information processing. Halcomb, McFarland, and Denny (1971) discuss this in the context of human time-sharing in vigilance studies. If these studies can be extended to say that the human mind functions along the lines of a single-server, single-channel, real-time computer, the concept of an area of stimulus overload is not only logical, but may someday be measurable as it is measurable today in computers through simulation of real-time applications and queuing formulas.[5]

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[5]for a discussion of simulation of real-time applications and queuing theory see Martin, J., Design of Real-Time Computer Systems, Prentice-Hall, 1967.

In a different approach from the effect of workspace stimuli
on a worker's arousal level, Herzberg, Mausner, and Snyderman
(1967) have analyzed the effect the physical workspace has
on the worker's motivation to work. They found that when
feelings of unhappiness where expressed, the feelings were
associated not with the work itself but with the conditions
surrounding the work. These conditions were interpreted by
the worker to be unfair and disruptive, and as such created
an unhealthy psychological work environment. Herzberg,
Mausner, and Snyderman (1967) refer to the factors that
create this unhealthy environment as factors of hygiene. In
regard to the physical workspace, the presence of harmful
factors of hygiene serves to bring about negative job atti-
tudes, but removal of these harmful factors will only serve
to remove the impediments to positive job attitudes, not
cause positive job attitudes.

The findings of Herzberg, Mausner, and Snyderman (1967)
that the workspace environment functions only as a dis-
satisfier is in agreement with the distractive nature of a
stimulus overload in arousal theory. One difference between
the two is the differentiation between the effects of good
and bad working conditions. In arousal theory, since no
distinction is made between good or bad working conditions,
either could provide an overload stimulus input to the key-
punch operator's senses that may result in a reduction in her
performance. In motivation-hygiene theory, however, bad

working conditions reduce motivation while good working conditions play a neutral role.

The approach of this thesis is that if the environment of the workspace is unpleasant in the eyes of the keypunch operator or so stimulating that it dominates her attention, then action should be taken to remove the factors causing the reduction. This removal action may not in itself foster a positive work attitude, but it will inhibit the negative effect the factors may have on the proposals of this thesis.

The following discussion is offered to provide assistance in determining what actions can be taken to improve the physical workspace.

A. COLOR AND LIGHTING[6]

Color can provide a strong stimulus input. Yellows and oranges are considered warm colors that are stimulating. Cool colors such as green, blue, and grey are relaxing. Pure colors are more distracting than subdued tones.

In the workspace, it has been found beneficial for workers to have a cool expanse of wall at least twenty feet away on which to rest their eyes. If the climate is hot, cool walls make it feel cooler while ivory or buff tones give an illusion of warmth.

Lighting should be within a forty to sixty foot-candle range and there are meters available to test installed

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[6]Cutting, R. A., M.D., "Fatigue," The American Peoples Encyclopedia, Grolier Inc., 1963, p. 8-349.

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lighting to see if this illumination is being provided. As
important is the requirement that the light not be glaring,
moving, or flickering.

B.  NOISE AND MUSIC

The amount of distraction due to noise is dependent upon
the nature of the noise and the worker's attitude towards it.
Some people become accustomed to noises that constantly
irritate other people. High and low frequency noises and
sudden noises above 45 decibels are particularly disturbing.[7]
Sound absorbing materials should be used in such situations
to deaden the noise. Carpeting the floor will deaden most
noises in keypunch, cut down on floor maintenance, and raise
the appearance of the installation. If employee partici-
pation is permitted in the selection process, carpeting can
be useful in raising employee morale.

Music is an unusual paradox. According to Poock and
Wiener (1966), rarely have so many people felt so strongly
for any entity that does so little towards improving pro-
ductivity. Commercial music system contractors may promise
all the benefits normally associated with music such as im-
proved morale, production, absentee rate, turnover rate, etc.
However, Poock and Wiener's studies into the actual effects
of music do not support these claims. They report that
while most workers desire music on the job, about 10% are

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[7]Ibid., p. 8-350.

annoyed by it, and in some cases music has even been observed to lower the quality of work.

Surface (1951) measured the metabolic rate of subjects performing a steady task under various noise and music situations. A decrease in metabolic rate under the music situation would have indicated the job was easier with the music or that music could be used to increase productivity with no increase in effort expended. The results showed no change in metabolic rate. His conclusion was that while statistical studies have shown an increase in productivity in some factories, these production increases were not achieved without an increase in effort expended.

Smith (1947) studied the effect of music on keypunch operators during breaks and lunch but not during work. An opinion poll of the operators showed 75% wanted the time increased, 90% felt happier on music days, and 50% felt the music had helped their work output. The actual results found no difference in number of cards punched, in the error rate, or in the absentee rate.

## IV.  THE WORKER

A premise of this thesis is that while the keypunch
operator is not viewed as an extension of her machine, her
performance in the workspace and her reaction to an in-
centive plan can be predicted.  To assist in this prediction,
the worker will be discussed as an individual and as a member
of a work group in the context of Atkinson's theories on
motivation to achieve success and motivation to avoid failure.
The strength of financial rewards to motivate employees to
increase productivity will be discussed via the work of
Opsahl and Dunnette.  A discussion will be presented on time
off from work as an alternative to financial reward as an
incentive.  In conclusion, a review will be offered of what
others have done to increase employee productivity.  This
review includes formal plans, the incentive pay plan currently
in use in the keypunch installation at the Navy's Ships Parts
Control Center, Mechanicsburg, Pennsylvania, and a few
examples of the approach some private industries are currently
taking.

## A.  THE INDIVIDUAL

Contingency Management deals with behavior modification
through controlling reinforcements and offers techniques use-
ful to data processing management.  According to Malott (1971),
Contingency Management first attempts to define its operation
through five rules.  The first rule is to be consistent.  The

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second rule is to restrict the application to a small area

in order to permit the concentration of administrative

efforts and to allow workers to concentrate their behavior,

learning fewer things, but learning them to a high level of

competence. The third rule is to establish functional be-

havior which Malott (1971) defines as behavior that will

continue as a result of reinforcements received from the

worker's peer group, work relationships, etc., after the

controls are removed. The fourth rule is to consider pre-

requisite behavior and not attempt to establish a particular

behavior pattern before all preliminary behavior patterns

have been developed. The last rule is to provide immediate

consequences for behavior where after each response, feed-

back is provided to strengthen correct responses and weaken

incorrect responses.

Malott (1971) defines a contigency as the relationship

between a behavior and its consequence. There are four

different contigencies:

> Positive Reinforcement - a reward presented after
> the behavior is emitted,
>
> Negative Reinforcement - an aversive event removed
> after the behavior is
> emitted,
>
> Avoidance - the presentation of an aversive event is
> delayed or prevented as a
> consequence of the desired
> behavior, and
>
> Punishment - an aversive event is presented after the
> behavior is emitted.

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Reinforcers can fall into two categories according to Malott (1971). Primary reinforcers are basic, unlearned reinforcers such as food and water. Secondary reinforcers are learned reinforcers such as money and social approval.

While this thesis does utilize a questionnaire to evaluate employee attitudes before and after implementation, no cyclic, routine methods·are provided for analyzing employee behavior. Therefore, the following discussion is offered in an attempt to forecast employee reaction to the implementation of this thesis and assist data processing management in determining which of the prior contigencies and secondary reinforcements should be applied. The normal worker and the marginal worker will be treated separately with the acknowledgement that a large grey area exists between these two groups where management must select the tools to best fit the varying conditions.

1. The Normal Worker

Teevan (1969) states that the normal worker will approach the job with both negative and positive motivations. Some work to gain whatever rewards are available while others work only because if they didn't work, they would fail. He emphasizes that when considering an incentive plan it is important to be aware of the differences between employees who are basically motivated to achieve success and those who are basically motivated to avoid failure because: "If one

does not recognize what these latter persons are trying to do, their behavior sometimes makes little sense."[8]

Atkinson, as reported by King (1970), states that one factor of total motivation (TM) is the motivation to achieve success (MS) minus the motivation to avoid failure (MF). King (1970) reports that if a worker measures low in both these traits he most likely falls into the category of the marginal worker, that an operator who measures in the moderate zone will probably be a good average worker, and that an operator who measures high in either extreme can be a disruptive influence that will require close management observation.

According to King (1970), the worker who has a tendency towards a higher motivation to achieve success will thrive on an incentive plan, providing the worker perceives a balance in the plan between his concept of the benefits to be gained (incentive value of success) and his personal estimate of the chances of success (probability of success). Atkinson, as reported by Wallace (1971), states that the incentive value of success and the probability of success can take on values from zero to one and that as the balance between the incentive value of success (IS) and the probability of success (PS) move away from the midrange values about 0.5 in an $IS = 1 - PS$ relationship, the total motivation

[8]Teevan, R. C., Fear of Failure and General Achievement Behavior, Buchnell University, 1969, p. 1.

of the worker begins to decline. If the incentive value of success and probability of success enter the range outside of 0.1 to 0.9, the worker becomes totally unmotivated to perform. This can be seen in his conceptualized formula of total motivation where:

$$TM = (MS - MF) \ (PS) \ (IS)$$

where:

TM = total motivation,
MS = motivation to achieve success,
MF = motivation to avoid failure,
PS = perceived probability of success,
IS = incentive value of success.

Thus, even though there may be tremendous value in performing difficult tasks (high IS), the motivation to perform these tasks, even by a person motivated to achieve success, will be quite low because of the level of difficulty expressed in the probability of success (low PS). Likewise, such a person does not want to waste his time on easy tasks of little value. A conclusion that might be drawn is that the person who measures high in motivation to achieve success may be initially happy as a keypunch operator but will soon be eager to move on to more rewarding jobs if she perceives the value of success low and the probability of success high. An incentive plan may offer sufficient benefits in recognition, money, and time off to keep her on the job, but, most likely, this operator will push for training on the other data processing machines or as a supervisor, and, if not forth-coming from the installation, will seek employment elsewhere.

Teevan's (1969) studies indicate that the degree to which a person is motivated to avoid failure appears to depend upon how he was treated by those responsible for his upbringing. Studies in early parental behavior have revealed that children of parents that emphasized early achievement tend to score in the higher or lower ranges of measures of fear of failure while children of parents that did not emphasize early development tend to be in the mid-range. The major determanent in whether a person scores high or low in measures of fear of failure appears to be the approach taken by his parents in emphasizing early achievement.

In surveys of both parents and their college-age children by Teevan (1969), a pattern has emerged. In cases of parents that reacted neutrally when the child came up to expectations but punished when he did not, the child tended to score high in fear of failure. Where parents reacted neutrally when their child did not come up to expectations the child tended to score low in measures of fear of failure. Where a combination of punishment and reward were utilized there was no pronounced tendency in the child. Additionally, parents of a lower occupational or educational level who stressed achievement seem to foster higher fear of failure tendencies.

Teevan's work indicates the worker who measures high in fear of failure should be of interest to data processing management because he can demonstrate characteristics

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that can be violently detrimental to an incentive plan based on performance. Teevan found that these workers prefer situations which do not lead to easy comparisons between themselves and others, a factor to remember when thinking of methods to promulgate performance results. If forced into achievement tasks they may yield outstanding results because they work so hard to avoid failure, but if they do fail, this will be remembered and used to reinforce future desires to avoid such tasks. They tend to volunteer for tasks that are either very easy (where success is assured) or for tasks that are impossible (where the penalties of failure are slight). Thematic apperception test stories by people who measured high in fear of failure displayed central characters that were more pawns than controllers of their environment.[9] Being externally oriented to the reactions of the group around them, such workers tend to conform to the standards of those whom they feel control the immediate rewards of their world, regardless of whether these standards are culturally acceptable. The standard setters may be data processing management, other workers, or people external to the workplace. Such workers tend to be hostile towards authority and lack the desire or ability to be good leaders.

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[9]A Thematic Apperception Test is a psychological tool where a subject is given a picture and asked to tell a story about what he sees. The psychologist then analyzes the story by comparing it to various lists of key words.

## 2. The Marginal Worker

Porter (1970) defines a marginal worker as an employee who historically demonstrates inconsistent attendance at the work place, has failed to meet the established standards of the organization and/or has failed to achieve an adequate level of performance. Motivating this type of employee can present a complex problem to management.

First, Porter (1970) contends, do not assume the marginal worker lacks the intelligence to perform the task. He is likely to be very aware of people and events, and highly sensitive to the slightest cues concerning the impact of his behavior on others. His attitude upon entering the workspace is masked by self-protection defenses that may appear hostile and alienate management. This attitude is generated in the main by his expectation that he will not be treated fairly in relation to other employees and can be especially true if he is also a minority group member.

Expectancy theory, as set forth by Vroom and Campbell and reported by Arvey and Dunnette (1970), distinguishes two types of expectancy of an individual about a task - Expectancy I: belief about whether or not the expenditure of effort will result in effective performance, and Expectancy II: belief about whether being an effective performer will lead to valued rewards. The emphasis is clearly on personal probability estimates where the worker's beliefs regarding

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whether his effort will result in effective performance has
a motivational effect on his performance. Porter and Lawler
(1968) support this relationship in their findings that the
value of a reward and the perceived effort-reward probability
combine to influence effort (and, in combination with ability
and role perception, to influence performance). Arvey and
Dunnette (1970) have found that in regard to the marginal
worker and expectancy theory, Expectancy I may be far more .
important in influencing job performance. If true, re-
structuring reward systems may be less useful in motivating
this type of worker than explaining to him exactly how his
job behavior relates to his becoming an effective performer.

In the context of an incentive plan for the marginal
worker, Porter (1970) states that the methods of administering
the incentive rewards are more important and should receive
more attention than the types of rewards. Fringe benefits,
in his opinion, are of little importance to the marginal
worker since they are distant in time from his current be-
havior and they are seldom contingent upon the quantity or
quality of performance. Profit sharing plans only induce
employees to stay with a company, not work harder. The point
Porter (1970) stresses is that the timeliness of the reward
is important. An incentive plan for normal workers will not
be sufficiently responsive for the marginal worker. Other
rewards of a simple nature must be developed so that the
incentive can be a reward of recognition.

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Porter (1970) believes the incentive should be used with the marginal worker in a fashion approaching the operant conditioning technique of shaping behavior by selectively reinforcing already existing responses in the marginal worker's repertory by applying positive or negative reinforcements as consequences of the behavior emitted. Shaping consists of reinforcing closer and closer approximations of the desired behavior. The reinforcement, according to Porter (1970), may be given on the basis of a schedule of reinforcement. A schedule of reinforcement, according to Reese (1966), is a statement of the contingencies on which reinforcement depends where the contingencies are specified in terms of the number of responses emitted and/or in terms of the passage of time. If the reinforcements used are rewards of recognition, Porter (1970) warns that recognition from management may be accompanied by undercutting from the worker's peers if they feel the reward is unwarranted and the worker may feel insulted if he also feels such recognition is unwarranted. Once the shaping has been completed and the initial behavior pattern has been established, the normal incentive plan should serve as a follow-on to reinforce the marginal worker's efforts over time.

B.  THE GROUP

From 1927 to 1932 a series of experiments were conducted at the Hawthorne Chicago Works of the Western Electric Company that were based on the assumption that worker

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productivity and complaints could be explained in terms of physical working conditions. Wassenaar and Oestreich (1972) report that it is difficult to overestimate the comprehensive nature of the Hawthorne experiments and offer as an example one part of the study which involved an analysis of 86,000 comments made by interviewees on 80 topics during approximately 10,000 interviews.

The experiments at Hawthorne were typical of a school of thought led by Frederick Taylor known as Scientific Management. Proponents of Scientific Management, according to Wallace (1971), believed that efficiency could be increased through careful selection and training of the worker and that the worker would put forth extra effort on the job in order to maximize his economic gain. An opposing school of thought at the time delt with Classical Organization Theory. The Classicist believed the structure of the organization was most important. Centralized or decentralized, tall or flat, and optimal sub-unit size were the critical elements. Wallace (1971) reports that, like the Scientific Manager, the Classicists gave little attention to the worker as a person.

The results of Hawthorne raised serious questions that could not be answered by either group. For example, Wassenaar and Oestreich (1972) report that three experiments were conducted to determine the effect of illumination on productivity. Two groups were established. One group experienced no

illumination changes while the other group was subjected
to changes in illumination varying between three and ten
foot-candles. The results were that: "both groups showed
a slow but steady increase in productivity. Only after the
illumination of the experimental group was decreased to that
of moonlight did the group's output decrease."[10] Other
experiments concluded with similar results. Clearly some
heretofore unknown powerful factors were operating to cause
the increases in productivity.

Wassenaar and Oestreich (1972) conclude that the Hawthorne
experiments taught the importance of the informal group in
on-the-job worker performance. They state these groups form
spontaneously, that group members frequently develop sub-
stantial unity and cohesiveness of thought and action, and
that the group can exert highly effective pressures to en-
force and maintain group norms and goals.

Studies performed since Hawthorne, as reported by
Forward (1969), have shown that group achievement motivation
is not solely a function of the individual motives which
members bring into the group situation. Rather, as Zander
(1970) states, the group as a functioning body has its own
achievement motives that can either supplement or contradict
the effect of the personal motives of the members.

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[10]Wassenaar, D. J. and Oestreich, H. H., The Hawthorne
Studies: A Summary and Critical Evaluation, Lansford
Publishing Company, 1972, p. 2.

Wallace (1971) reports that because of Hawthorne, a new doctrine arose dealing with human relations, but that the Human Relations school became the other extreme - people without organizations. A later school dealing in human potentialities has since argued that the Human Relations school only gives the worker the impression he is important and what is really needed is more emphasis on meaningful worker participation.

Each of the above schools of thought emphasize elements important to a data processing installation. Employee selection and development, the effect of the organization on the employee and the employee's effect on the organization are important. Group size is a factor in the extent individual motives can interact with and either supplement or contradict group motives. Wallace (1971) has found that small work groups have less need for dominant leadership and experience less attitude change as conditions change while Rothe (1960) has found that small groups take higher pride in success and produce about 6% more than large work groups regardless of the pay system.

Zander (1970) has found that while individual motives and group motives are independent, they display identical characteristics. Like individuals, groups can be motivated to achieve success or motivated to avoid failure. The motivational direction of one group may be quite different from another even though both have members in common.

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Motivation to achieve success has been observed to be more likely aroused in a strong group than a weak one, in a successful group than in a failing one, in core members than in peripheral members, and in groups where success is perceived to be the normative group response.

There may be considerable difference from one group to another on whether the members emphasize their desire for group success or personal achievement. Studies by Zander (1970) have shown a tendency for more mature, more competent males to have interests in group achievement and for younger, less capable females to polarize about desires for personal success. Realizing this, data processing management should ask what can be done so that the keypunch operators can achieve their own goals best while directing their efforts towards organizational objectives.

The extent of member desire for group success is measurable in group output, and in some cases, member self-regard is affected by the degree of group performance. In the Hawthorne studies, Wassenaar and Oestreich (1972) state that the customs and values established by the group were more important to individual members than working conditions or cash benefits. However, one factor that did show a continuous relationship with improved output, according to Sutermeister (1963), was the mental attitude of the workers. His hypothesized cause of this attitude change was that the workers were responding favorably to the increased attention they were receiving.

The effects of group motivation are important to an incentive plan because if the group decides to reject the plan by condeming the rate busters, little will be gained. If small groups of equivalent competence can be formed, group motivation may be hightened through competition and the publication of general group achievement levels. Whatever the situation, apparently it is not sufficient that most individuals express an interest in an incentive plan; the group as one body must also support the plan.

## C. THE STRENGTH OF MONEY AS A MOTIVATOR

Opsahl and Dunnette (1966) define an incentive as: "an object or external condition, perceived as capable of satisfying an aroused motive, that tends to elicit action to obtain the object or condition."[11] Financial rewards are commonly used as the incentive object, but they report that in spite of the many incentive plans that have been implemented during this century and the huge sums of money that have been spent, very little is known about how money interacts with the behavior of the worker. In their report they have listed five major hypotheses concerning the role of money in affecting worker on the job behavior. These hypotheses are:

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[11]English, H. B. and English, C. A., A Comprehensive Dictionary of Psychological and Psychoanalytical Terms, McKay, 1958.

## 1. Money as a Generalized Conditioned Reinforcer

Many support the hypothesis that money acts as a generalized conditioned reinforcer because of its repeated parings with various primary reinforcers.[12] Generalized because it applies to many reactions. Conditioned because it has no initial intrinsic value of its own but must be repeatedly associated with or paired with items of value in order to eventually envoke a response when present alone. Most of the knowledge about the strength of such reinforcers, Opsahl and Dunnettee (1966) conclude, has unfortunately been derived from studies with animals and the results involving money have been limited and inconclusive.

## 2. Money as a Conditioned Incentive

If a child performs some act that pleases its mother, she may reward it with a cookie and thereby reduce a primary drive - hunger. If the child liked the cookie, the expectation of a second cookie may provide the incentive to perform the act again. Once this primary incentive is established, it may be repeatedly paired with money until money also becomes an incentive by conditioning. This hypothesis is very similar to the hypothesis of conditioned reinforcement just discussed. The main difference being that here money is treated as an object capable of affecting drive reduction.

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[12]Opsahl and Dunnettee (1966) reference Holland, Skinner, Kelleher, Goleub.

3. Money as an Anxiety Reducer

When a child sees a parent experiencing a painful stimulus, such as the mother burning her hand on the stove, the child notices the emotional expression exhibited. Later when similar emotional expressions are displayed in pairings with a lack of money, the child feels anxiety related to the prior painful experiences. As an adult this person finds money to be an effective anxiety reducer. Opsahl and Dunnettee (1966) conclude, however, that there is no firm evidence to either support or disclaim this theory.

4. Money as a "Hygiene Factor"

Opsahl and Dunnettee (1966) refer to Herzberg, Mausner and Snyderman in a hypothesis that money can only be used to avoid dissatisfaction ("Disease") and not to promote increased motivation ("Health"). Again, they state little evidence is available to support this hypothesis.

5. Money a. a Tool to Gain Desired Outcomes

Vroom has offered a hypothesis that Opsahl and Dunnettee (1965) support as being most likely. According to Vroom, money is given a value equal to its perceived ability to obtain other desired outcomes such as security, a new car, a house, etc. In an approach similar to Atkinson's total motivation theory, Vroom equates the probability of a worker making a money-seeking response to the strength of his desire for the outcome multiplied by his personal probability estimate that these responses will successfully lead to

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more money.  In the context of an incentive plan this hypothesis is the best alternative interpretation since it will equally support any of the previous hypotheses about the value of money and its role in worker on-the-job behavior.

The basis of virtually every payment scheme is the equality of benefit received (payment) for benefit contributed (productivity) in relation to other worker/employer alternatives.  If this equality does not hold for the employer, the workforce, the employee, and the employee's social contacts, the relationship may be broken by either the worker or the employer depending on how they view the inequality.  For groups of workers performing a common task, the payment has degenerated to a common payment based on the contribution of the group.  There is no requirement in such a situation for a worker to perform above average expectations of the employer, especially where the supply of workers is less than the demand for such workers at the current wage rate or where group pressures discourage "rate busters."

Attempts have been made to increase production by identifying group or individual productivity and tailoring payments to the observed output.  Group level plans, however, have drawbacks similar to the straight payment system.  In groups, especially larger groups, the worker has great difficulty in relating his performance to the group's contribution.  The efficiency of an incentive plan is considerably dulled in this situation.

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The effects of individual payments are complicated by
the fact that incentive plans are not implemented in a vac-
uum. Implementation requires a closer worker management
relationship which alone can foster increases in productivity
as was demonstrated in the Hawthorne study previously dis-
cussed. Often such plans are accompanied by workspace
environmental improvements which also cloud the effect of
the incentive plan. This is not to say such actions are bad.
Actions that promote increased productivity are welcomed
providing that they can be maintained over time or, if they
should be gradually discontinued, their absence will not
cause an even lower level of productivity.

Opsahl and Dunnette (1966) support Lawler's contention
that if the pay plan is administered in secrecy it reduces
money's effectiveness as a knowledge-of-results device that
lets the employee evaluate his performance-to-reward relation-
ship. They believe that most fears of pay disclosure stem
from fear by salary administrators that they could not pro-
vide convincing arguments to support their present practices
in regard to relating job performance to salary payments.

In publicizing the results of an incentive plan data
processing management must effectively deal with the double
approach-avoidance conflict, reported by Opsahl and Dunnette
(1966), that is presented by the respective rewards and
punishments offered by management and the work group, without
destroying either. The incentive plan represents a potential

reward to the individual while different publishing methods vary in their detrimental effect on group unity.

The recommendation of this thesis will be to plot the results of measuring worker productivity on a simple graph in the workspace. For a small installation, shift against shift may be a logical grouping. For larger units, each shift may be broken into smaller teams. To go to the individual level is considered detrimental since it holds an individual employee up to public scrutiny and is a heavy-handed method of dealing with the slow or marginal employee. Besides, workers in small groups are well aware of the abilities of individual group members.[13] Group pressure under a shift or team concept will accomplish much more without the risk of channeling group unity against data processing management.

## D. AN ALTERNATIVE TO MONEY

Money has been described as a tool to gain other desired outcomes. One desired outcome is leisure time that is best described in terms of microeconomics.

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[13]Hollander, E. P., "Validity of Peer Nomination in Predicting A Distant Performance Criterion," Journal of Applied Psychology, Vol. 49, No. 6, 1965, p. 434-438, reports that the results of peer ratings are significantly valid in predicting ability to perform and that friendships do not have a major intrusive effect on the validity of the ratings.

According to Peterson (1971), the decision to spend time at leisure means to forego a certain amount of income. The price of an hour of leisure is the income foregone by not working that hour.

The market supply of labor is described by Peterson (1971) as an increasing function where the amount of labor offered by the work force will increase as the wage rate increases. Specifically, at a particular wage rate the workers will offer a certain number of hours of labor. As the wage rate increases, the cost of an hour of leisure also increases and a substitution effect of the workers trading hours of leisure for hours of labor is experienced. The workers by working more hours at a higher wage rate now have a higher income which they can use to purchase additional hours of leisure. This income effect results in the workers partially withdrawing their offer of additional hours of labor. The overall result of the substitution and income effects is the offering of additional hours of labor at the increased wage rate.

The behavior of the market supply of labor is determined by summing the labor supply behavior demonstrated by individual workers as they offer various hours of labor in return for various wage rates. Ferguson (1972) states that considerably more can be said about the sum than about the constituent parts because the individual worker may offer any sequence of labor hours at various wage rates. If the

sequence is similar to the constantly increasing function previously described, the financial incentive offered by this thesis should prove attractive to that individual. If the wage rate increases reach a high level where the income effect of a bigger paycheck with which to purchase leisure hours dominates the substitution effect of trading leisure hours for labor hours for a particular worker, increases in the wage rate may only lead to reductions in the number of labor hours that individual offers. Since the point at which the income effect starts to dominate the substitution effect varies from worker to worker, the incentive plan proposed by this thesis will give the keypunch operator the option of trading incentive financial rewards for leisure hours.

E.  WHAT OTHERS HAVE DONE

The remainder of this chapter concentrates on what others have done in attempts to increase worker productivity. The first part deals with a discussion of several formal in-centive plans, some of which were developed in the late 1800's. The second part presents a discussion of the key-punch incentive plan at the Navy's Ships Parts Control Center. The third and final part reports on the direction several private firms have taken to increase productivity through "job enrichment."

Niebel (1958) divides what he calls direct wage financial plans into two classifications. One is where the worker

receives direct payment in relation to a set standard of performance and the other is where the cost savings due to performance above this standard are shared by the worker and his employer. Under the first classification he discusses five plans, the first four of which have no guaranteed minimum income.

The first plan, straight piecework, is where all standards of performance are given in terms of dollars per unit produced. The worker receives no base salary and is only paid on the basis of his exact unit production. This method was used more than any other plan prior to World War II because of its simplicity, but the method was discontinued because rapidly changing base pay rates since World War II created an untenable clerical burden in updating the standards.

The standard hour plan is the second plan and is very similar to straight piecework just discussed. The difference is that in the standard hour plan, standards of performance are stated in terms of units of output per unit time. The immediate advantage over straight piecework is the elimination of the clerical update effort because the standards do not change when base pay rates change. The immediate disadvantage is that it is more difficult for the worker to evaluate his performance.

Taylor Differential Piece Rate, the third plan, used two different straight piecework rates. A low piecework rate was applied until a standard performance output level was reached, beyond this point a much higher piecework rate

was used. This method is not popular today because it penalizes the average and slower worker and, due to its use of very high standards, only rewards the few exceptional workers.

Due to severe employee criticism of the Taylor Differential Piece Rate plan, the Merrick Multiple Piece Rate plan was introduced. This plan established three piecework rates. One rate for beginners, one for average workers, and one for superior workers. Because it was based on piecework rates and because of the unpopularity of the Taylor plan, the Merrick plan did not meet with success.

Measured daywork is the fifth plan and was established as a result of organized labor's effort to end piecework rates. Under measured daywork a worker established a base wage rate over three months of observation. He is then paid at this rate for the next three months regardless of his production, but his production will determine the base wage rate that will be applicable for the next three months. Measured daywork was not a success because of the time separation of performance and the reward, the detrimental effect of three months at a low rate, and the amount of clerical work required to maintain detailed records on each employee's wage and production rate.

Niebel (1958) concentrates on four additional formal plans in a discussion of the type of plan where the employee is guaranteed a minimum income and shares with his employer

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all cost savings created by performance above standard.
These plans were primarily established to protect employers
from runaway piecework rates that were erroneously estab-
lished due to the absence of accurate time study techniques.

The first plan, known as the Halsey Plan, was estab-
lished in 1890. It set performance standards in units of
output per unit time. Workers that produced above standard
split the resultant cost savings 50/50 with the employer.

The Bedaux Point System was established in 1916 and
was more complex than the Halsey Plan. Basically, the Bedaux
Point system's design is such that each job is qualified by
the number of "B's" required to complete the job. Each "B"
is equal to one minute of time that is composed of pre-
determined proportions of work and rest depending upon the
difficulty of the job. The average worker had to complete
60 "B's" each hour. If the worker performed over standard,
he was paid his base salary plus an amount equal to the
number of excess "B's" earned multiplied by his wage rate
per minute multiplied by seventy-five percent.

The Rowan Plan introduced in 1898 set a standard time
for each job. The incentive was calculated on the basis
of the ratio of time saved to this standard time. Since no
worker can save more than the time allowed, an effective
ceiling is placed on the amount of incentive that can be
earned.

The Emerson Plan is similar to the Rowan Plan except that a small incentive is provided when a worker produces in the 66 2/3% to 100% range of standard and a straight 20% for all production above 100% of standard.

The major objection  to each of these four plans, according to Niebel (1958), was that unlike the piecework rates which were growing in popularity during this time, they were not directly related to production and they required involved calculations.  This thesis does not consider either of these objections important.  Piecework rates are no longer popular and the power of the computer will be routinely utilized for all calculations.

Caro (1971) outlines various incentive plans in use in the Navy.  These plans include beneficial suggestion rewards, one time meritorious performance awards, and meritorious pay step increases.  According to Caro (1971), they presuppose the presence of satisfactory working conditions, adequate supervision, and fair pay for a day's work.  In regard to what has been stated in this thesis, the largest drawback of Navy incentive plans is the untenable delay between performance and reward that renders them impractical for daily production.

In the later part of 1969 the Central Data Processing Division of the Navy's Ships Parts Control Center at Mechanicsburg, Pennsylvania, instituted an incentive awards program for keypunch unit personnel.  The program consists of

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establishing production standards for each job for keypunch and verification operations. Each operator's performance is matched against the standard and quarterly bonuses are awarded on the basis of productivity ranges above standard.

The standards are established based on two main categories. The first is the quality of the source document. The elements of evaluation are: (1) legibility, (2) continuity of fields, (3) procedure complexity, (4) number of different transactions, (5) color contrast, and (6) size of the document. From these elements a composite rating of excellent, good, fair, or poor is established. The second category is the number of card columns punched and duplicated. For each of the four ratings there is a separate Production Range Table as shown in Table I for punching and verifying, for a total of eight tables. The tables are matricies of acceptable production ranges in cards per hour. The ordinates of the matrices are the number of card colunms duplicated and the number of card columns punched. As an example, the acceptable production range for punching an excellent rated job consisting of 45 columns of punching and 17 columns of duplication is from a low of 197 cards per hour to a high of 225 cards per hour.

Upon receipt of job batches the keypunch supervisor reviews the input documents and separates them into workable batches if necessary. The supervisor records the start and stop production time and the operator's number. The elapsed

# TABLE I

## PRODUCTION RANGE TABLE

Type of Operation:                                      Punch

Source Document Classification:         Excellent

### CC'S DUPLICATED

| CC'S PUNCHED | 0-7 | 8-15 | 16-23 | 24-31 | 32-39 | 40-47 | 48-55 | 56-63 | 64-71 | 72-79 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1-8 | 840 552 | 777 524 | 724 499 | 677 477 | 636 456 | 600 437 | 567 419 | 538 403 | 511 388 | 487 386 |
| 9-16 | 554 412 | 526 397 | 501 382 | 478 369 | 457 356 | 438 344 | 421 334 | 404 323 | 389 322 | |
| 17-24 | 413 329 | 398 319 | 383 309 | 370 301 | 357 292 | 345 284 | 334 277 | 324 276 | | |
| 25-32 | 330 274 | 320 267 | 310 260 | 301 254 | 293 248 | 285 242 | 277 241 | | | |
| 33-40 | 274 234 | 267 229 | 260 224 | 254 219 | 248 215 | 242 214 | | | | |
| 41-48 | 235 205 | 229 201 | 225 197 | 20 193 | 215 193 | | | | | |
| 49-56 | 205 182 | 201 179 | 197 176 | 194 175 | | | | | | |
| 57-64 | 182 164 | 179 162 | 176 161 | | | | | | | |
| 65-72 | 164 149 | 161 148 | | | | | | | | |
| 73-80 | 149 138 | | | | | | | | | |

CARDS PER HOUR

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time includes all time expended except for lunch since a 15% personal time allowance has been built into the Production Range Table. Periodically the production statistics are processed to determine an individual production rating for each employee by comparing the actual number of cards processed to the production range. If the actual number of cards processed is within the range, the rate is 100%. If the actual number is below the lower boundry, the lower boundry is divided into the actual number of cards processed and the quotient represents the production rating. If the actual number is above the higher boundry, the higher boundry is divided into the actual number of cards processed and the quotient represents the production rating. Using the prior example, if 150 cards had been punched, the production rating would be 150 divided by 197 or 76%. If 200 had been punched, the rating would be 100%. If 250 had been punched, the rating would be 250 divided by 225 or 111%. The production rating is tempered by the number of errors made by an operator. An error rate of 2% to 3% reduces the rate by 3%, an error rate of 4% to 6% reduces the rate by 10%, and so on.

To qualify for an incentive award an operator must work a minimum of 350 hours of measured production during the quarter, have an error rate of 3% or less, and be satisfactory in all phases of performance and conduct. The award table shown in Table II is used with the qualification that: "the

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# TABLE II

## QUARTERLY PRODUCTION RATE MONETARY AWARD TABLE

| QUARTERLY PRODUCTION RATE | QUARTERLY MONETARY AWARD |
|---|---|
| 115-124% | $25 |
| 125-134% | $35 |
| 135-144% | $45 |
| 145-154% | $55 |
| 155-164% | $65 |
| 165-174% | $75 |
| 175-184% | $90 |
| 185-up | $100 |

incentive awards plan was designed so that approximately 25% of the operators would qualify for awards each quarter. Should the number of operators qualified for an award exceed the 25% goal, we are obligated to adjust the table."[14]

There are two major limitations in this plan. First, using Atkinson's theory of motivation, both the incentive value of the award and the probability of success are low, thus resulting in low motivation for many employees to really work hard at playing the game. The second limitation is the time isolation of the reward from the labor that earned the reward. In the opinion of this thesis, three months is too long, one month is too long, even one hour is too long. The ideal would be for the data entry machine to display a productivity index upon completion of the last punch. This may seem impossible, but with the introduction today of the on-line mini-computer for controlling key-to-disk data entry systems, the potential is there; all that is needed is the software.

There is a trend in private industry towards "humanizing" monotonous jobs by providing increased "job enrichment" through eliciting employee participation in work decisions previously dictated by management.[15]

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[14]Navy Ships Parts Control Center, Central Data Processing Division, Standards and Procedures Manual, "EAM Standards and Procedures," Section 10, Chapter 1, Subject 2, p.2.

[15]U. S. News & World Report, "The Drive to Make Dull Jobs Interesting," July 17, 1972, p. 50.

According to Myers (1970), meaning is given or returned to work through a process known as job enrichment or job enlargement. He states that job enrichment may result from horizontal and/or vertical job enlargement. He defines horizontal job enlargement as an increase in the variety of functions performed at a given organizational level with the intention of first relieving boredom and then broadening the worker's perspective in order to pave the way for vertical job enlargement. Vertical job enlargement enables workers to participate in planning and control functions that had been previously reserved for supervisory and management personnel.

In implementing job enrichment procedures, organizations are becoming flatter with authority and responsibility being shifted downward in response to the increasing education level and changing values in the society.[16] According to Secretary of Commerce Peter G. Peterson, the young worker: "has different expectations and attitudes than workers in the present generation. Business must take account of that, look into the work environment it is providing. It must consider sharing profits, joining with the workers in a mutual commitment to boost production instead of squaring off and fighting."[17] Gary B. Bryner, 29, President of

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[16]Ibid.

[17]Ibid.

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United Auto Workers Local 1112, has said: "the attitude of

young people is going to compel management to make jobs more

desirable in the workplace and to fulfill the needs of man...

the attitude that a guy goes to work and slaves to get his

$4 an hour is passé. The guys want to feel like they're

making real contributions. They don't want to feel like a

part of the machines."[18]  Bryner backed up these statements

by striking General Motor's new showcase plant at Lordstown,

Ohio, for one month on the basis that the jobs were too dull

and the pressure too intense.

Some industries are trying to capitalize on the known

satisfaction derived from completing a task from start to

finish. Many production assembly lines have been abolished

for one worker assembling and testing the complete product

as evidenced by the following examples offered by U.S. News

& World Report.[19]

The hot-plate division of Corning Glass Works at Medfield,

Massachusetts, abandoned the assembly line in 1965-66. Now

each worker assembles and tests each hot-plate. Together the

employees schedule their work to meet a weekly objective,

suggest refinements and improvements, and devise their indi-

vidual techniques. The operator's pride is solicited and

accountability for quality is assured by requiring his initials

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[18]Business Week, "Job Monotony Becomes Critical,"
September 9, 1972, p. 108.

[19]U. S. News & World Report, p. 50-54.

on the final product.  The results have well justified the approach.  Rejects have fallen from 26% to 1%; absentecism from 8% to 1%.  As a result, this approach has spread throughout the plant and a team approach has been implemented in complex tasks.

At Donelly Mirrors, Inc., of Holland, Michigan, all workers are on a production related incentive plan with a team approach organization headed by a foreman.  The foreman can grant a day off to any worker for any reason.  The workers decide how much of an annual salary increase they receive and then must find ways to pay for it.  Salaries have increased 25.5% in the past three years and they have been paid for in higher production, reduced costs, and elimination of unnecessary jobs.

In company after company the results of employee recognition can be seen.  Monsanto textiles is using a classroom approach to get the worker:  "to realize that he is not an extension of a machine, and to draw on his abilities to think, plan, and innovate for the good of all."[20]

General Electric at Columbia, Maryland, has emphasized recognition and participation:  "Each employee is the supervisor's responsibility, he gives them recognition, rewards them, counsels them, and coaches them."[21]  Rap sessions,

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[20] Ibid., p. 52.

[21] Ibid., p. 53

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freedom in dress, and a strong equal opportunity program contribute towards their success.

Gains Pet-Food Plant in Topeka, Kansas, has taken a rotating team approach to processing, shipping, and office duties. There is one door for all to enter and leave, one lunchroom, and no reserved parking places.

At the Oak Brook, Illinois, plant of McDonald's Corporation, worker's wear casual clothes on Friday and leave work at noon. Time is made up by coming to work a half-hour early each day. The only segregated areas with doors are the rest rooms.

What has happened is that these companies have come to realize that the employee is their most valuable asset. Harry Heltzer, Chairman and Chief Executive Officer of Minnesota Mining and Manufacturing Company, has stated that, "Too many managers have the idea that the way to get better productivity is to stand over the worker with a club and make him push the wheelbarrow faster."[22] According to Dr. Michael Beer, Manager of Organizational Research and Development at Corning Glass Works, "This is an effort to deal with the changing needs of the work force. We have to manage to fit those needs, adapt to change in fast-changing industries. In the past, we have vastly underestimated what a person is capable of.

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[22]Business Week, "Management Itself Holds the Key," September 9, 1972, p. 143.

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Now we give them an opportunity to grow into the job. Not
all employees can do it, but I think a large percentage can.
I think this concept will snowball. It may be an answer to
the whole question of productivity."[23]

Myers (1970) warns against slavish emulation of any one
particular firm's approach to job enrichment and urges develop-
ment of job enrichment procedures particularly adapted to the
installation in question. Several elements of this thesis
are intended to provide the beginning steps towards job
enlargement in keypunch. The Procedure Time Model, which is
the foundation of the proposed incentive plan, is adjusted
over time on the basis of observed performance in an attempt
to allow the keypunch operator to set her own standards and
goals. The easy recording and exclusion of training time
from the incentive work period will facilitate data processing
management's offering the keypunch operator a continuous
opportunity to learn on the job. Through the use of negative
reinforcements the proposed incentive plan encourages quality
workmanship. The report output includes a detailed operator
technical performance evaluation that is intended to be used
by the unit supervisor in individual counselling of the
operator or all aspects of her performance. The counselling
should emphasize the relationships between the goals of the
operator and those of the installation. These procedures

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[23]U. S. News & World Report, p. 54.

are beginning steps; each installation must review its own
operation. One approach suggested by Myers (1970) is to
form a task force composed of a vertical cross section of the
firm. For data processing such a cross section would start
with the Keypunch Unit Supervisor and continue through the
Director. The task force should study the various methods
available as suggested by Myers (1970) and situational
descriptions, then, on a continuing basis, analyze, plan,
develop, and implement procedures that will enable the
installation to benefit from the potential of the individual
operator.

## V.  MEASURING ATTITUDES

Changes in employee attitude towards the job will be measured using a questionnaire survey technique and the results analyzed to determine the effect of the various job enrichment and motivational procedures recommended in Chapter IV.  Measuring worker attitudes is important because productivity increases should not rely solely on economic incentives and machinery improvements.  "Other motives, such as ego, security, curiosity, and creativity are employed to enhance productivity through favorable attitudes."[24]

According to Massee (1971), management must be able to see the relationship between its behavior and the results of the survey questionnaire.  If the results are unfavorable, management must resist the natural urge to reject the findings and, instead, implement corrective procedures.  If management chooses to reject unfavorable findings as being untrue, Masse (1971) states the resultant conflict between superiors' and subordinates' evaluations of role performance and effectiveness will inhibit individuals from freely communicating important job matters with their superiors.

Porter and Lawler (1968) state that:  "Attitudes traditionally have been studied by psychologists because they can

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[24]Masse, S., "The Questionnaire Survey Technique," The Journal of Navy Civilian Manpower Management, Vol. V, No. 3, Fall 1971, p. 10.

provide important insights into human cognitive processes, and, ultimately, because they can contribute to the understanding and prediction of human behavior."[25] Much of what is being recommended by this thesis deals with behavior modification. The results can be partially determined in terms of increased productivity as measured in record output per unit time, but since the recommended hardware changes alone are expected to increase productivity, some measure should be used to distinguish between productivity increases due to hardware and productivity increases due to behavior modification.

Two survey questionnaires are included in this thesis. The questionnaire in Table III is to be administered to the keypunch operator and the questionnaire in Table IV is to be administered to the shift supervisors and the unit supervisor. The questionnaires are to be administered prior to any indication that the ideas in this thesis are to be implemented. The questionnaires should be administered a second time after the recommendations have been implemented and the installation has become accustomed to the system and the benefits of employee counselling. The results of the two surveys should then be analyzed to determine what changes have occurred and what future modifications in managerial policies may be required. If the task force concept suggested by Myers (1970)

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[25]Porter, L. W. and Lawler, E. E., III, Managerial Attitudes and Performance, Irwin-Dorsey Limited, 1968, p. 2.

that was discussed in Chapter IV is utilized, the installation may choose to administer this type of questionnaire at infrequent intervals of time in order to provide the continuous feedback of information needed to further develop the process.

## TABLE III

### KEYPUNCH OPERATOR

|  |  | AGREE | ? | DISAGREE |
|---|---|---|---|---|
| 1. | Management is doing its best to give us good working conditions......... | ( ) | ( ) | ( ) |
| 2. | My boss is too interested in his own success to care about the needs of employees........................... | ( ) | ( ) | ( ) |
| 3. | My boss gives us credit and praise for work well done................. | ( ) | ( ) | ( ) |
| 4. | Management here does everything it can to see that employees get a fair break on the job.............. | ( ) | ( ) | ( ) |
| 5. | My boss sees that we have the things we need to do our jobs...... | ( ) | ( ) | ( ) |
| 6. | My boss sees that employees are properly trained for their job..... | ( ) | ( ) | ( ) |
| 7. | Sometimes I feel that my job counts for very little in this organization | ( ) | ( ) | ( ) |
| 8. | They expect too much work from us around here........................ | ( ) | ( ) | ( ) |
| 9. | I'm paid fairly compared with other employees........................... | ( ) | ( ) | ( ) |
| 10. | The people I work with get along well together...................... | ( ) | ( ) | ( ) |
| 11. | I have confidence in the fairness and honesty of management.............. | ( ) | ( ) | ( ) |
| 12. | My boss lets us know exactly what is expected of us..................... | ( ) | ( ) | ( ) |
| 13. | The people who get promotions around here usually deserve them.......... | ( ) | ( ) | ( ) |
| 14. | My boss has the work well organized | ( ) | ( ) | ( ) |

15. How often during the past year has your boss
    discussed his evaluation of your work performance
    with you?

                        8 - 12 times or more.......... (   )
                        5 - 7 times................... (   )
                        3 times....................... (   )
                        2 times....................... (   )
                        1 time........................ (   )
                        No time....................... (   )

16. How satisfied are you with your boss's discussions
    with you about your work performance?

                        More discussion than I desire..(   )
                        Discussion was about right.... (   )
                        More discussion is needed..... (   )
                        Much more discussion is needed (   )

17. Do you know what your boss wants you to get done
    during the coming year?

                        Yes; we have discussed it..... (   )
                        I have a pretty good idea..... (   )
                        I'm not sure.................. (   )
                        I have no idea as to his
                        expectations.................. (   )

18. How aware is your boss of the job you have to do
    and how well are you doing it?

                        He pretty well knows what is
                        going on...................... (   )
                        Most of the time he is well
                        aware......................... (   )
                        Sometimes he is aware......... (   )
                        Rarely is he aware............ (   )
                        When he does give it attention,
                        he doesn't understand what's
                        going on...................... (   )

19. Is your boss objective in evaluating those he supervises?

                        He sees things the way they are(   )
                        Most of the time he is........ (   )
                        Many times he is fooled by his
                        people........................ (   )
                        It is easy for his people to cover
                        up their poor performance..... (   )
                        He doesn't evaluate, or he goes
                        by personality rather than work
                        performance................... (   )

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# TABLE IV

## SUPERVISOR

|  |  | AGREE | ? | DISAGREE |
|---|---|---|---|---|
| 1. | Management is doing its best to give us good working conditions......... | ( ) | ( ) | ( ) |
| 2. | My boss is too interested in his own success to care about the needs of employees.......................... | ( ) | ( ) | ( ) |
| 3. | My boss gives us credit and praise for work well done................. | ( ) | ( ) | ( ) |
| 4. | Management here does everything it can to see that employees get a fair break on the job.................... | ( ) | ( ) | ( ) |
| 5. | My boss sees that we have the things we need to do our jobs............. | ( ) | ( ) | ( ) |
| 6. | My boss sees that employees are properly trained for their jobs.... | ( ) | ( ) | ( ) |
| 7. | Sometimes I feel that my job counts for very little in this organization | ( ) | ( ) | ( ) |
| 8. | They expect too much work from us around here........................ | ( ) | ( ) | ( ) |
| 9. | I'm paid fairly com···d with other employees.......... .............. | ( ) | ( ) | ( ) |
| 10. | The people I work with get along well together...................... | ( ) | ( ) | ( ) |
| 11. | I have confidence in the fairness and honesty of management.......... | ( ) | ( ) | ( ) |
| 12. | My boss lets us know exactly what is expected of us..................... | ( ) | ( ) | ( ) |
| 13. | The people who get promotions around here usually deserve them.......... | ( ) | ( ) | ( ) |
| 14. | My boss has the work well organized | ( ) | ( ) | ( ) |

15. How often during the past year has your boss
    discussed his evaluation of your work performance
    with you?

    8 - 12 times or more............... (    )
    5 - 7 times........................ (    )
    3 times............................ (    )
    2 times............................ (    )
    1 time............................. (    )
    No time............................ (    )

16. How satisfied are you with your boss's discussions
    with you about your work performance?

    More discussion than I desire........... (    )
    Discussion was about right.............. (    )
    More discussion is needed............... (    )
    Much more discussion is needed.......... (    )

17. Do you know what your boss wants you to get done
    during the coming year?

    Yes; we have discussed it............... (    )
    I have a pretty good idea............... (    )
    I'm not sure............................ (    )
    I have no idea as to his expectations... (    )

18. How aware is your boss of the job you have to do
    and how well you are doing it?

    He pretty well knows what is going on... (    )
    Most of the time he is well aware....... (    )
    Sometimes he is aware................... (    )
    Rarely is he aware...................... (    )
    When he does give it attention, he
    doesn't understand what's going on...... (    )

19. Is your boss objective in evaluating those he supervises?

    He sees things the way they are......... (    )
    Most of the time he is.................. (    )
    Many times he is fooled by his people... (    )
    It is easy for his people to cover up
     their poor performance................. (    )
    He doesn't evaluate, or he goes by
     personality rather than work performance(    )

20. How often during the past year have you specifically
    discussed your evaluation of the work performance of
    your operators (those you directly supervise) with them?

    8 - 12 times/man or more................ (    )
    5 - 7 times/man......................... (    )
    3 - 4 times/man......................... (    )
    2 times/man............................. (    )
    1 time/man.............................. (    )
    No times or only with a few............. (    )

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## VI.   THE INCENTIVE PLAN

The incentive plan offered in this chapter is designed to
increase the marginal physical product of labor by providing
an incentive object in the form of money or time off that may
be earned by the individual keypunch operator in reward for
her demonstrated increased productivity.  The keypunch in-
centive plan is centered around a Procedure Time Model for
each documented keypunch procedure.  This model is initially
mathematically predetermined on the basis of the results of a
time test, but adjusted over time to reflect the current pro-
ductivity level of the installation.  Daily system inputs
include production data at the job level from the operator
(or her machine), supervisor input on non-productive operator
hours (training, leave, etc.), and input on the jobs that are
backlogged.  A series of computer programs, written in COBOL,
are used to create the system and to produce a periodic re-
port output tailored to the organizational structure.

The following sections outline the action required to
create and maintain the Procedure Time Model, the system
files, the input data collection procedures from machine
operations and the supervisor, the calculation of production
effectiveness and incentive hours earned, the basic reports,
and the MUACS option for Naval Supply Centers.

### A.   THE PROCEDURE TIME MODEL

Before a job or employee can be measured, a ruler must be
provided.  This ruler must accurately represent existing

conditions if it is to be the base of a payroll system, provide a continuing competitive incentive, and portray an up-to-date comparative measure of unit productivity. The ruler for this thesis is the Procedure Time Model. "Procedure" because there is one time model for each recognized and documented keypunch evolution. "Time" because time is a unit of measurement that is both convenient and universal to all jobs and installations. "Model" because it is an idealized representation that describes the keypunch evolution for one procedure and reveals important relationships between the operator, her machine, and the source document. The use of modeling permits the indication of relevant data, facilitates dealing with the entire problem, and permits the use of the computer to perform the analysis of data and consolidation of results.

A logical property of a model is that its solution is only good as long as the model is good. For this reason, the Procedure Time Model is not a time standard in the sense of Time and Motion Study. Rather, it is a self-adjusting level-of-performance indicator that will be used in comparison with actual operator output. This concept yields two major benefits to management. First, the accuracy of the initial Procedure Time Model, while important to the speed at which the system stabilizes, is not critical to the long run ability of the system to perform. Second, the population of Procedure Time Models will be moulded over time to the particular characteristics of the particular installation, taking into lump-sum

consideration the difficult to measure variables such as environment attitude, personality, effect of social status rewards in off-the-job relations, and a multitude of other variables. For the operator the system offers a realistic, accurate, and competitive yardstick for the equitable distribution of rewards on the basis of personal effort and ability.

Initially the time model must be established as if the "average worker" were available for measurement. The acceptable methods for establishing time standards are through the use of Standard Data, Time Study, Methods Time Measurement, and/or Work Sampling. The details of these methods will not be discussed here since they are readily available from any primer on Time and Motion Study.[26] All are valid methods but all require talented specialists and a considerable amount of time. Considering that an activity may have one hundred, two hundred, or more different keypunch evolutions this task can become an untenable expense if it were to be done manually. Fortunately, through the use of the computer, the time required to establish these initial benchmarks can be greatly reduced as can be the expertise requirements of the personnel providing the information. While this may raise a question of accuracy, accuracy is an economic, not an engineering consideration. With the self-adjusting properties of the

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[26]See Niebal (1958).

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Procedure Time Model the slight loss in accuracy is of little

relevance when compared to the significant savings in imple-

mentation manpower cost.  Additionally, it might be questioned

as to how accurate one can get.  Accuracy here can only be

validated over time since there is no "exact" way to do a

particular keypunch operation.  What works for one operator

may not work for another.  The Procedure Time Model thus must

attempt to determine an average time to do an operation.  If

the operator performs identically to the Procedure Time Model

approximation, the job will be accomplished as planned.  The

probability,  however, is greater that the operator will

deviate from the planned path.  If the operator performs with

an expectable degree of intelligence and skill the time

actually consumed and the planned time will be about the same.

If it differs, the Procedure Time Model must be sufficiently

flexible to move in the direction of the variance while

historically retaining for data processing management review

the relative magnitude and direction of the evolution.

1.   Initial Creation of the Procedure Time Model

The creation of the Procedure Time Model is a complex

process of meshing many variables into a best estimate of

productivity.  The sequence of events that will be described

in detail starts with the documentation of every acknowledged

keypunch procedure.  Most installations already have this

documentation and so this step is at most a clerical process.

At the same time, the experience of the unit supervisor is

called upon in the selection of a representative cross-section of established procedures routinely performed by the installation. Keypunch operators from the installation will perform one or more of these procedures and be timed. The results of this time trial will be combined with the procedure documentation in the predetermination of the Procedure Time Model. The end result when combined with an Operator Identification File will be the system file ready for implementation.

(a) Units of Measurement

The basic unit of measurement of the system is the "Time Measurement Unit." The Time Measurement Unit is a term familiar to Time and Motion Study and is referred to as a "TMU." Table V shows the conversion of TMU's to standard clock time.

If the Procedure Time Model is to be predetermined with sufficient accuracy to enable initialization and stabilization of the system within an effective time frame, the relationships of the various elements that comprise a keypunch evolution must be defined. While many elements will vary significantly from installation to installation based on everything from the color of the walls to the personality of the supervisor, the fact that all keypunches function basically on the 64-character standard keyboard permits the declaration of the primary procedure elements as constants. These primary procedure elements are shown in Table VI and apply to mechanical punches of the IBM 029 variety.

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## TABLE V

### TMU - TIME MEASUREMENT UNIT CONVERSION TABLE

| | | | |
|---|---|---|---|
| 1 TMU | = | .00001 | hours |
| 1 TMU | = | .00060 | minutes |
| 1 TMU | = | .03600 | seconds |
| | | | |
| 1 Hour | = | 100,000 | TMU's |
| 1 Minute | = | 1,670 | TMU's |
| 1 Second | = | 28 | TMU's |

## TABLE VI

### PRIMARY KEYPUNCH PROCEDURE ELEMENTS

| Procedure Elements | Unit of Measurement | Equivalent Level of Difficulty |
|---|---|---|
| Numeric | Columns | 1.00 |
| Alphabetic | Columns | 1.20 |
| Alphameric | Columns | 1.40 |
| Manual Duplication | Columns | 0.60 |
| Manual Skipping | Columns | 0.08 |
| *Auto Duplication | Columns | 0.30 |
| *Auto Skipping | Columns | 0.04 |
| | | |
| Manual Dup/Skip | Times | 2.20 |
| *Auto Dup/Skip | Times | 1.20 |

*delete for machines that electronically duplicate and skip.

For machines that electronically duplicate and skip, the asterisked procedure elements in Table VI that deal with automatic duplication and skipping should be deleted.

The first group of the primary keypunch procedure elements listed in Table VI is self-explanatory in that they

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are standard functions of the machine operation. The equivalent levels of difficulty were estimated with numeric punching as a base with a weight of 1.00 per column punched. Accordingly, aphabetic punching is slightly more difficult and a larger weight is attached to that type of activity. The remaining elements of the first group were established in the same manner. Concerning the last group of two primary procedure elements, the operations of duplication and skipping require a shift in the concentration of the operator. This shift is compensated for by adding a TMU factor for each occurrence.

There are additional known differences in procedures due to the source document. The evaluation of these differences, while mainly subjective, are, nevertheless, well know. to the operator and it is advantageous to include this knowledge in the predetermination of the Procedure Time Model. Procedures can be complicated due to poorly engineered documents that require the operator's eyes to jump around the document. Carbon copies, poor penmanship, and documents filled with irrelevant data can all add to the time requirements of a particular procedure documentation. The units of measurement for the evaluation consist of subjective ratings of excellent, good, fair, or poor.

(b)  Preparation of Procedure Documentation

Preparation of the procedure documentation for each keypunch evolution is basically a clerical operation,

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but it is beneficial to have the work performed by a key-punch operator experienced in the various procedures performed at the installation. The documentation consists of three records - a header, the entry format, and the verification format. The formats of these records are shown in APPENDIX B. The header contains the procedure number, a suffix (for multiple record outputs), source document evaluation ratings, and record size. Additional optional entries are provided for procedure name and MUACS code. The entry and verification format records consist of standard format control records (i.e., IBM 029/059 program drum control cards).

There will undoubtedly be a few jobs that cannot be documented such as "Punch Print Return," "999," "Corrections," or any of the other tags used to describe miscellaneous jobs that escape from true identity. Also, the installation may have instituted various "Hotline" operations that vary from low volume inputs of standard procedures to miscellaneous and correction punching with no verification. Such operations, due to their extremely variable nature, will not qualify for earning incentive hours and will not be documented.

Remote terminal operations also vary greatly from installation to installation. At the present time this function will be excluded from this thesis although the desirability of including this increasingly important activity is strong.

Each keypunch procedure will be reviewed for
legibility (penmanship - typed or handwritten), contrast
(original or carbon, colored paper), continuity of fields
(degree of jumping around on the document), difficulty
in handling (large or multiple source documents), and com-
plexity (front and back information, document filled with
irrelevant data, etc.).  The procedure is rated in each of the
above areas as being excellent, good, fair, or poor.  These
ratings are then entered in the header card as specified in
the header card format in APPENDIX B.  Since it is possible
to more than double the time allowed for any job through the
results of the source document rating, the reviewer must be
consistent and accurate in his evaluation.

The documentation is then reviewed for accuracy
of coding via the COBOL Computer Program Number 1.  In return,
the keypunch supervisor will receive the input documentation
cards and an error listing in the same sequence as the input.
Once the errors have been corrected and re-validated, the
documentation is held pending completion of the time trials.

(c)   Time Trials

The Procedure Time Model is predetermined on the
basis of how long it takes the particular installation to
punch and then to verify one character of numeric data.  These
two time factors are obtained from a series of time trials
and entered by a programmer into the program that calculates
the initial Procedure Time Model.

The time trials are based on representative samples of procedures and operators. Since this thesis is applicable to any keypunch installation, only rough guidelines can be offered as to proper sample sizes. The ultimate sample sizes selected should be determined on the basis of desired accuracy and the cost of conducting the trials. If the installation has 150 documented procedures and 30 operators, the recommendation would be to select 15 jobs and use all 30 operators.

Once the procedures have been selected based on their representative nature of the type of work performed by the installation, fictitious batches are created from actual source documents. The batch size should be such that the data entry operation will consume 15 to 20 minutes. Each participating entry and verifier operator is then assigned and timed on their performance in completing the job. The operator should be allowed to set up the job and machine prior to starting the trial and use a format control record (program drum card) if this is typically done for the procedure being performed. The time should be recorded from first punch to last punch with the operator proceeding at her normal speed. It is recommended that the time recorder not stand near the operator during the trial. Upon completion of the time trial, the procedure number and time result should be recorded with the entry and verification trials being kept separate through all trials and subsequent calculations. If any entry

operation results in more than a 3% error rate, that time

trial must be rejected and the task repeated by another

operator because jobs with more than a 3% error rate would

invalidate the follow-on verification time trial.

The TMU factors for entry and verification will

be calculated using the formula shown in Table VII.  The

calculations must be performed twice.  Once using only the

entry results and once using only the verification results.

The entry and verification TMU factors are then

patched by a programmer into Computer Program Number 2 that

calculates the predetermined Procedure Time Model and creates

the system file.  The TMU factors are patched into the pro-

gram so that they will be readily available in the future when

changes and adds are processed that will require recalculation

of the Procedure Time Model.

2.  Routine Adjustment of the Procedure Time Model

Daily, jobs are received, batched, and completed by

the keypunch installation.  Each batch has a control form

which upon completion of the job is retained by the keypunch

supervisor.  The accumulation of these batch control forms

over the month provides the input to the program that adjusts

the Procedure Time Models.  The results of actual monthly

production is averaged with the Procedure Time Model by

Computer Program Number 4 using the formula in Table VIII.

The formula uses a moving four month average of actual pro-

duction in addition to the predetermined procedure time in

TABLE VII

## CALCULATION OF THE BASIC NUMERIC TMU FACTOR

$$\text{TMU FACTOR} = \frac{\sum_i t_i}{\left[\sum_j \sum_i n_{ij} f_j\right]\left[\dfrac{1.2 - (0.04)\left(\sum_K c_k\right)}{N}\right]}$$

where:

$t_i$ = results of time trials for trials i = 1, 2, ...

$n_{ij}$ = number of occurrences of the procedure elements j = numeric, alpha, ... for trials i = 1, 2, ...

$f_j$ = equivalent levels of difficulty for procedure elements j = numeric, alpha, ...

$c_k$ = numeric conversion of the five quality ratings of the source document for k = 1, 2, ..., 5 where the rating excellent = 1, good = 2, ..., poor = 4 (see page 75).

$N$ = number of time trials

## TABLE VIII

## ADJUSTMENT OF THE PROCEDURE TIME MODEL

$$\text{PROCEDURE TIME MODEL} = \frac{2p + a_c + \sum_{i=1}^{3} a_i}{6}$$

where:

p = Predetermined Procedure Time Model

$a_c$ = actual production data for the current month

$a_i$ = actual production data for prior months i = last month, 2 months ago, and 3 months ago.

KEYPUNCH PROCEDURE REPORT

JANUARY 1972

| JOB-NR | M | PROCEDURE NAME | DATE | SIZE | -RATINGS- | D A T A   E N T R Y | | | | | | | V E R I F I C A T I O N | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | STROK | PRED | 3-MO | 2-MO | 1-MO | USE1 | USE2 | STROK | PRED | 3-MO | 2-MO | 1-MO | USE1 | USE2 |
| 001000 | E | JOB NR. 1000 | 15 12 72 | 60 | G G E E F | 70 | 500 | 510 | 520 | 500 | 490 | 500 | 60 | 400 | 410 | 425 | 390 | 400 | 400 |
| 002000 | | JOB NR. 2000 | 15 12 72 | 60 | G G E E F | 80 | 600 | 610 | 620 | 600 | 580 | 500 | 50 | 500 | 510 | 520 | 490 | 500 | 500 |
| 003300 | E | JOB NR. 3300 | 15 12 72 | 60 | G G E E F | 70 | 500 | 510 | 520 | 500 | 490 | 500 | 60 | 400 | 410 | 425 | 390 | 400 | 400 |
| 005000 | E | JOB NR. 5000 | 15 12 72 | 80 | G E F P G | 70 | 500 | 520 | 500 | 500 | 500 | 420 | 60 | 400 | 425 | 390 | 400 | 400 | 336* |
| 006000 | | JOB NR. 6000 | 15 12 72 | 60 | G G E E F | 80 | 600 | 620 | 600 | 333 | 600 | 459 | 50 | 500 | 520 | 490 | 278 | 500 | 381* |
| 007000 | D | JOB NR. 7000 | 15 12 72 | 75 | P P P P F | 65 | 700 | 720 | 700 | 306 | 700 | 521 | 60 | 600 | 590 | 620 | 263 | 400 | 446* |
| 007001 | | JOB NR. 7001 | 15 12 72 | 60 | G G E E F | 80 | 600 | 610 | 620 | 600 | 580 | 600 | 50 | 500 | 510 | 520 | 490 | 500 | 500 |
| 008000 | D | JOB NR. 8000 | 15 12 72 | 120 | P P F G E | 100 | 900 | 900 | 900 | 900 | 890 | 900 | 95 | 850 | 850 | 850 | 850 | 850 | 850 |
| 008300 | E | JOB NR. 8300 | 15 12 72 | 60 | G G E E F | 70 | 500 | 510 | 520 | 500 | 490 | 500 | 60 | 400 | 420 | 425 | 390 | 400 | 400 |
| 009000 | | JOB NR. 9000 | 15 12 72 | 60 | G G E E F | 80 | 600 | 610 | 620 | 600 | 580 | 600 | 50 | 500 | 510 | 520 | 490 | 500 | 500 |

TABLE IX

PROCEDURE TIME MODEL REPORT

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order to dampe. any violent or sudden changes on the basis
that such deviations are unusual, and while they may key a
trend, cannot be deterministic in major model shifts. The
original predetermined estimate carries a double weight in
the formula and serves two purposes. First, if the instal-
lation experiences large productivity gains, the predetermined
estimate holds the model back thus giving the operators a
greater initial reward. It prevents the standard from
reaching the new high thus guaranteeing continuing rewards
for universal outstanding productivity and provides a con-
tinuing incentive to maintain this high level. Also, it
softens the blow of any sudden drop in productivity from this
high level. The second reason for including the predetermined
estimate is in the case where productivity declines below the
initial level. In this case the predetermined level will
assist in keeping the carrot before the cart, highlight low
productivity, and protect a downward spiralling installation
by slowing the decline of the model.

The new Procedure Time Model will be used the
following month. The reason for the delay is to give manage-
ment a full opportunity to review the recalculation and take
action in the case of questionable deviation. The report
shown in Table IX will be provided. The report lists all
procedures first in procedure number sequence and then again
in procedure number sequence within percent change in
Procedure Time Model.

3.  Sensitivity Analysis

There are many factors that can change the productivity
level of an installation. Some are subtle and occur without
identification, some are dramatic and of obvious origin. Some
are difficult to measure and all will rapidly invalidate any
fixed productivity indicator. The basis of this system, the
Procedure Time Model, is an indicator that will slowly drift
upward or downward as changes occur to effect productivity.
It can accommodate many factors, but some could create such a
large shift in productivity that it would be better to start
over and recalculate the predetermined time model

(a)  Factors that Suggest a Need for Recalculation

The most obvious need for recalculation would be
a change in hardware. Such changes are usually made due to
aspirations for higher productivity. It is best in such cases
to recalculate after the operators have a few months experience
on the new machines and new time trials are run.

(b)  Factors for which Adjustment can be Automatic

Minor changes in the workspace environment,
organization, or personnel can be accommodated by the Pro-
cedure Time Model update. Any new procedure or change to an
existing procedure will involve a recalculation, but the re-
calculation is performed automatically by the program that
updates the system file. If management disagrees with any
resultant model, methods are available to set the time where
desired via a management override card.

B.  THE OPERATOR IDENTIFICATION FILE

The Operator Identification File is an input to the system file.  The Operator Identification File consists of one record for each keypunch employee.  This includes all keypunch supervisors but not remote terminal operators.  The operator identification record contains the operator's name, number, shift, pay grade, and step.  The format of this record is provided in APPENDIX B.  The Operator Identification File is combined with the procedure documentation and processed by Computer Program Number 2 in the creation of the system file. Operator identification records coded add, change, or delete are also processed by this program in follow-on updates to the system file.

C.  THE SYSTEM FILE

There is one file in the system and it can be maintained on cards, tape, disk, drum, or data cell with appropriate modifications to the COBOL program file description and the Job Control Language (JCL).  The file contains three records - the operator identification record, the procedure description header, and the Procedure Time Model.  The format of each of these records is provided in APPENDIX B.

The files are created and updated by Computer Program Number 2.  The input to the program consists initially of the Operator Identification File and the procedure documentation. Updates are performed by the same program by inputting

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operator identification and procedure documentation records

coded add, change, or delete as described in the input

description documentation for Computer Program Number 2.  Any

Procedure Time Model can also be changed by a management over-

ride card which is a specially coded card in the format of the

Procedure Time Model record as shown in APPENDIX B and

described in the input description documentation for Computer

Program Number 2.

D.  INPUT DATA COLLECTION

Many of the new key-to-tape, key-to-disk and buffered

punch hardware systems will provide production data either in

the form of a punched card or a data bank that can be retained

until requested.  Such methods are superior to manual methods

since they are usually more accurate and reduce the clerical

operation time of entering such data in a utilization log.

For the purpose of this system, however, a batch control form

will be utilized to provide uniformity and ease of future

modif. ition as the newer hardware becomes available.

In addition to the production statistics obtained from

the batch control form, the supervisor is responsible for re-

porting exception utilization of employee manhours and a

daily measurement of all work queued for processing.

1.  The Batch Control Form

The batch control form, shown in Table X, will arrive

in keypunch or at a keypunch hotline with the procedure block

## TABLE X

### THE BATCH CONTROL FORM



and number of source documents block already completed. In
the main keypunch unit, the supervisor is responsible for con-
trol over all jobs. If the data entry hardware does not have
a record counting capability, the supervisor must verify the
record count. Additionally, many requests do not contain an
economical batch size and must be bundled together with a
master batch control form, processed, and separated again by
the supervisor after job completion.[27] Some jobs contain too
many records for one employee to efficiently start and complete
in the remaining time available; such jobs must be split apart

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[27]The definition of an economical batch size varies from
installation to installation. An economical batch according
to this thesis will be a batch that contains sufficient source
documents to occupy an operator for 45 to 50 minutes.

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by the supervisor, separate batch control forms attached, processed, and rejoined by the supervisor at job completion time. The point being made is that the supervisor should not be a pail passer in the local fire brigade. Rather, the supervisor should exercise control over batch sizes to obtain economically sized jobs and equitably distribute the work to the operators.

Upon receipt of a job, the operator will enter her two digit operator number and the start time. The verifier will make the same entries plus an additional entry on the number of cards that contained errors. All operators will enter the appropriate two letter pay code if they are working other than regular time, i.e., night time differential (NT), over-time (OT), compensatory time earned (CE), or holiday premimum (HP). As each operator completes the job she will enter the stop time. If there were no errors, the corrections section will be left blank. If the verifier operator makes the corrections, only the verifier column is completed. If a keypunch operator makes the corrections and then a verifier operator verifies the corrections, the two operators will enter the production data in the corrections block identically to the way it was entered in the initial process block. Since correction time is not considered as qualifying time for in-centive calculations, the start and stop times for such operations must be entered on the batch control form by the supervisor when the job is assigned and returned completed.

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The operators at the hotline stations will receive
the same batch control form on jobs submitted but need only
complete the initial process sect'on by entering their operator
numbers and pay type if other than regular. Any additional
clerical effort would be detrimental to the function of hot-
line. Since there is presently no incentive plan for hotline
operators, some equitable rotation plan should be initiated
by the installation for these employees.

Upon completion of the keypunch and verification
evolution the batch control form is removed by the supervisor
and retained for punching and inputting to the system. In
commands where it is desirable to have a copy of the batch
control form continue on with the job or be returned to the
user, the printing of the form on carbonless (NCR) paper has
been beneficial.

It should be noted that while the job start and stop
time is written on the batch control form during the initial
processing of the job, elapsed job time is not a production
effectiveness data element. The production effectiveness
and incentive reward calculations are based on comparing the
time allowed by the Procedure Time Model to the time available
for production. The time available for production is defined
as the workday less all authorized absences such as breaks,
correction time, and those operations listed in Table XI. For
this reason, the Supervisor Exception Log, to be discussed next,
is of importance to the system.

## 2. The Supervisor Exception Log

The keypunch supervisor must provide data on all
exception utilization of employee manhours. Such reporting
will include all types of absenteeism, training, clerical,
and non-standard keypunch assignments. The shift supervisor
will enter in the Supervisor Exception Log, shown in Table
XII, the total number of hours each employee spends each day
performing the duties listed in Table XI.

## TABLE XI

### EXCEPTION WORK CODES

| OPERATIONS | CODE |
|---|---|
| Clerical work.................................. | CL |
| Formal classroom training...................... | TF |
| On-the-job training or informal training...... | TJ |
| Training assignment to the TAB room........... | TB |
| Annual leave................................... | LA |
| Sick leave..................................... | LS |
| Holiday leave.................................. | LH |
| Administrative leave........................... | LE |
| Compensatory time taken........................ | CT |
| Assignment to a Hotline (keypunch)............. | HK |
| Assignment to a Hotline (verifier)............. | HV |
| Assignment to a remote terminal (temporary)... | RM |

The Supervisor Exception Log may be maintained in
either a log book, a lined pad, or a special form. It should
be similar to the format shown in Table XII. The operator's
numeric operator number (1 to 3 digits) will be entered
followed by the work code from Table XI. The time so spent
in hours and tenths will be entered as will the appropriate
pay scale code from Table XIII.

## TABLE XII

### SAMPLE SUPERVISOR EXCEPTION LOG

| DATE | OPERATOR NUMBER | WORK CODE | HOURS & TENTHS | PAY TYPE |
|------|------|------|------|------|
| 12/15/72 | 05 | LA | 8.0 | |
| | 10 | TF | 1.0 | |
| | 12 | CT | 8.0 | |
| | C7 | | 5.7 | ND |
| | 07 | TJ | 3.0 | ND |
| | 25 | | 5.7 | ND |
| | 25 | | 1.0 | OT |
| | 25 | | 1.0 | NS |

## TABLE XIII

### PAY CODES

| FUNCTION | CODE |
|------|------|
| Regular time.................................. | BLANK |
| Night-time differential during normal shift hours | ND |
| Night-time differential outside normal shift hours while earning overtime, holiday premium, or compensatory time........................ | NS |
| Overtime....................................... | OT |
| Earning compensatory time..................... | CE |
| Holiday premium............................... | HP |

The supervisor exception log will also be used to
accurately report employee manhours spent earning additional
pay such as overtime or night-time differential.  The super-
visor will enter the operator's number as before, but the
work code will be left blank since the actual work performed
will be reported via a batch control form or another super-
visor log entry.  This entry is only to accurately report
exception time for payroll purposes, not to report what work

was done. The time will be entered in hours and tenths followed by the pay type from Table XIII. The following explanations are offered of the entries in the sample log to help clarify the use of the log.

OP NR 05 - took one day annual leave.

OP NR 10 - Had one hour formal classroom training.

OP NR 12 - Took one day off after having earned 8 hours compensatory time.

OP NR 07 - A normal swing shift employee who received her normal 5.7 hours of night-time differential and three hours of on-the-job training during the part of her shift where she was earning night-time differential.

OP NR 25 - A normal swing shift employee who received her normal 5.7 hours of night-time differential but after the end of the shift, worked an additional hour of overtime. Since she normally earns night-time differential, she will also earn night-time differential while she is earning overtime but because it is outside her normal hours, the code used is "NS" vice "ND."

3. Backlog Statistics

Backlog statistics are reported as of a fixed time each day for input to the optional MUACS routine for Naval Supply Centers. Since the term "backlog" is open to many interpretations, it will be defined as being all work in progress and queued for processing. The format shown in Table XIV will be utilized to record the necessary information. Either a log book or a lined pad should provide a satisfactory form.

The supervisor will enter the date in the log and the procedure number of each job backlogged. If the job is at the point where both punching and verifying are required, the code entry will be left blank. If the job has been punched but not verified, the code "V" will be entered in the code column. The input document count from the batch control form will be entered as the volume.

TABLE XIV

BACKLOG STATISTICS LOG

| DATE | PROCEDURE NUMBER | CODE | VOLUME |
|------|------------------|------|--------|
| 12/15/72 | 238D2 | | 1,000 |
| | 038S1 | | 345 |
| | 038S1 | | 986 |
| | 038S1 | | 543 |
| | C38S1 | V | 245 |
| | 465D2 | V | 123 |
| | 543A1 | V | 253 |

E. CALCULATING PRODUCTION EFFECTIVENESS AND THE INCENTIVE REWARD

Two calculations are made in evaluating employee performance. The first is to calculate a production effectiveness indicator that will be used for comparing group performance, employee performance, and performance trends. The second calculation is to determine the incentive rewards earned.

Employee production effectiveness is determined by taking the ratio of how long the job should have taken to how much

time was available to do the job.  The time allowed to perform

a job is calculated by multiplying the respective Procedure

Time Model by the volume of records in each job performed.

Because no operator can or will work 60 minutes of every

hour or maintain top speed throughout the day, an extra

allowance is applied for Personal, Fatigue, and Miscellaneous

time.  This allowance is in the form of a management set per-

centage of total allowed keying time with 15% being used in

this thesis.  An additional five minutes per job is added to

account for set-up time.  The time available to perform the

work is calculated by taking the basic time available or 7.5

hours (8 hours less 1/2 hour to account for two authorized 15

minute breaks) and subtracting all non-productive time re-

ported in the Supervisor Exception Log and time spend in making

or verifying corrections.  This ratio is shown in the formula

in Table XV.

The incentive reward calculation uses the same concept of

available time and the production effectiveness indicator in

determining the number of incentive hours earned.  These hours

earned may either be reported as incentive hours earned for

pay or time off purposes depending upon the option selected by

the operator.  The incentive reward calculation employs an in-

centive base factor that determines at which point incentive

calculations are to start.  In a labor market where the hours

of work offered by the workers equals the hours of employment

offered by management this factor is 100.  If the market is

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## TABLE XV

### PRODUCTION EFFECTIVENESS FORMULA

$$PE = \left[ \frac{\dfrac{p \left( \displaystyle\sum_{i=1}^{n} m_i v_i \right)}{100,000} + \dfrac{n}{12}}{7.5\, t_a - t_e} \right] - \left( -4 + \frac{7}{3}e \right)$$

where:

$p$ = Personal, Fatigue, and Miscellaneous Time Factor (set at 1.15 for 15%)

$m_i$ = Procedure Time Model time in TMU's (100,00 TMU = 1 hour) for job $i = 1, 2, \ldots$

$v_i$ = record volume of job $i = 1, 2, \ldots$

$n$ = number of jobs performed

$t_a$ = time available expressed in work days

$t_e$ = summation of the exception times reported in the Supervisor Exception Log and the time spent making or verifying corrections.

$e$ = average error rate if 2% or more (applied only to the keypunch PE portion of overall PE)

such that the supply of worker hours is below the hours required at a particular wage rate, the incentive base factor may be decreased as necessary in order to generate the increased wage rate needed to secure employees. The advantage here is that no modification need be made to a formal wage plan used for other employees and the incentive wage plan can be used to adjust to labor market fluctuations. The formula for incentive hour calculations is shown in Table XVI.

TABLE XVI

INCENTIVE HOURS FORMULA

$$\text{INCENTIVE HOURS} = \left[ 7.5\, t_a - t_e \right] \left[ \frac{PE - I}{200} \right]$$

where:

$t_a$ = time available expressed in work days

$t_e$ = summation of the exception time reported in the Supervisor Exception Log and the time spent making corrections

$PE$ = Production Effectiveness

$I$ = Incentive base. A base effectiveness level from which incentive calculations will be made. This thesis will consider all performance above 100% ($I = 100$) as qualifying for incentive rewards.

There are three critical data elements in the calculations of Production Effectiveness and Incentive Hours that demand careful attention. These elements are the Procedure Time Model, the input volumes, and the inputs from the Supervisor Exception Log. If any one of these inputs is reported in error either through design or neglect, the incentive hours earned would be wrong and the results could be expensive in terms of payroll funds and employee attitude. If these three elements are monitored, the system will provide an incentive whose limit is dictated only by the probability of an operator surpassing the average performance of the installation. For example, if an operator performs 120 hours of work in 80 hours, she will receive 20 hours of incentive pay or time off, but

the probability of any operator performing 120 hours of work in 80 hours is very small. Since this system has never been implemented, no actual ceiling has been observed. Nevertheless, an attempt at predicting system cost behavior will be made in Chapter VIII.

The report shown in Table XVII is produced by Computer Program Number 3. The report is provided at the individual, shift, and installation total levels. The individual level report is provided for employee counselling and performance evaluation. The shift reports and competitive group reports are provided for publication of group competitive indicators on a simple graph in the workspace and review by the unit supervisor. The installation level report is provided for review by higher levels of data processing management.

## F. MUACS OPTION FOR NAVAL SUPPLY CENTERS

As a part of the Defense Integrated Management Engineering Systems Survey Program (DIMES) the Management Utilization and Control Standards Program, or MUACS, was developed for use in the Naval Supply Centers. MUACS is designed to measure employee productivity for all tasks performed at a Naval Supply Center. It consists of a table of standards that are matched with actual employee performance to form a ratio of employee productivity. The standards for keypunch are engineered standards based on Time and Motion Study where, like this thesis, the unit of measurement is the Time Measurement Unit expressed in hours where 1 TMU = .00001 Hours.

PRODUCTION REPORT - INDIVIDUAL

DODSON, GLENDA    OPERATOR NUMBER 3:2    SHIFT 1    GRADE GS-03    STEP 02    REPORT FOR MARCH 1972

| INCENTIVE TIME AVAILABLE | INCENTIVE TIME ALLOWED | KEYPUNCH ERROR RATE | PRODUCTION EFFICIENCY RATE | INCENTIVE HOURS EARNED | EMPLOYEE UTILIZATION RATE |
|---|---|---|---|---|---|
| 64.0 | 70.3 | 0.0% | 109.0% | 2.6 | 80.0% |

| FUNCTION | JOB ORDER | RG REGULAR | ND NITE DIFF | OT OVER TIME | CE COMP EARN | HP HOL PREM | TOTALS |
|---|---|---|---|---|---|---|---|
| NORMAL PRODUCTION | | | | | | | |
| KP EASY | 622A 00108 | 14.5 | 0.0 | 0.0 | 0.0 | 0.0 | 14.5 |
| KP NORM | 622A 00109 | 38.1 | 0.0 | 0.0 | 0.0 | 0.0 | 38.1 |
| KP DIFF | 622A 00110 | 35.3 | 0.0 | 0.0 | 0.0 | 0.0 | 35.3 |
| VR EASY | 622A 00111 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| VR NORM | 622A 00112 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| VR DIFF | 622A 00113 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| MISCELLANEOUS | | | | | | | |
| CLERICAL | 6224 00110 | 22.9 | 0.0 | 0.0 | 0.0 | 0.0 | 22.9 |
| CORRECTION | 6224 00110 | 12.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.0 |
| TRAINING | 620N 00082 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| OJ TRAIN | | | | | | | |
| TAB RCOM | 6212 00100 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| ABSENT FROM WORK | | | | | | | |
| ANNUAL LV | 620N 00150 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SICK LV | 620N 00151 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HOLIDAY LV | 620N 00158 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ADMIN LV | 620N 00160 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| COMP TKN | | | | | | | |
| HOTLINE OPERATIONS | | | | | | | |
| KEYPUNCH | 622A 00117 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| VERIFY | 622A 00118 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| REMOTE OPERATIONS | | | | | | | |
| ALL | 621A 00101 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTALS | | 80.0 | 1.0 | 1.0 | 0.0 | 0.0 | 82.0 |

TABLE XVII

PRODUCTION REPORT    (INDIVIDUAL)

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The actual performance is reported in workunits completed
(records punched or verified) and the time consumed to per-
form the task.  For example, if a standard allowed .00620
hours per record punched and an operator punched 1000 records
in 7 hours, the production efficiency would be (.00620 x
1000) / 7 = .885 or 88.5%.

The report shown in Table XVIII is provided as an
optional feature of Computer Program Number 3.  It lists the
work units (record count) completed and backlogged under the
various production categories of the MUACS system.  It is
designed to facilitate the data collection effort for the
Naval Supply Center MUACS system, but may provide information
of interest to any data processing installation.

MUACS REPORT

| | | WORK UNITS: | COMPLETED | BACKLOGED |
|---|---|---|---|---|
| NORMAL PRODUCTION | | | | |
| KP EASY | 622A | 00108 | 2,000 | 100 |
| KP NORM | 622A | 00109 | 4,400 | 200 |
| KP DIFF | 622A | 00110 | 3,500 | 300 |
| VR EASY | 622A | 00111 | 2,000 | 100 |
| VR NORM | 622A | 00112 | 4,400 | 200 |
| VR DIFF | 622A | 00113 | 3,500 | 300 |
| HOTLINE OPERATIONS | | | | |
| KEYPUNCH | 622A | 00117 | | |
| VERIFY | 622A | 00118 | | |

TABLE XVIII

DIMES/MUACS REPORT   (optional)

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## VII. SELECTION OF KEYBOARD DATA ENTRY SYSTEMS

In the family of data entry equipment, genus "keypunch," there are four species: card punch and card verifier, buffered card punch/verifier, key-to-non-compatible and key-to-compatible computer tape, and key-to-disk or drum. Depending upon the volume and nature of the data preparation evolution, each machine could be optimal in the data processing environment.

Card punch and card verifiers of the IBM 029 and 059 variety are direct descendants of the machines in use over the past seven decades.[28] Their use is best confined today to small decentralized operations and areas where the electronics expertise of maintenance personnel may be a problem (i.e., combat zones, shipboard use). The primary drawbacks of this equipment are that: (1) mechanical speeds are significantly slower than electronic speeds in duplication and skipping, (2) error correction is clumsy, (3) separate machines are required for entry and verification, (4) there is an 80-column limitation per record, (5) it is difficult to selectively verify multiple card records, (6) errors caught by computer validation must recycle through the entire process, and (7) mechanical equipment is subject to greater wear than electronic circuits.[29]

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[28]Cary, Robert F., "A History of Keyboard Data Entry Equipment," DATAMATION, June 1970, p. 79.

[29]EDP ANALYZER, Vol. 9, No. 10, October 1971, p. 11.

Buffered card punch/verifiers of the UNIVAC 1710/1701
and IBM 129 variety represent the latest evolution in card
punching. They are vastly superior to the prior types in
that they perform all entry operations electronically in one
80-column buffer, while the alternate 80-column buffer is
being mechanically punched. For operations that cannot
eliminate their dependency on the punched card, this is the
best alternative.

Key-to-non-compatible and key-to-compatible computer tape
are similar to each other except that the former uses tape
cartridges and the latter uses standard computer tape reels.
The advantage of this type of equipment is that the 80-column
barrier is potentially broken, and yet each station is a stand
alone machine. Disadvantages include (1) relatively high
set-up time, (2) difficulty in interrupting jobs, (3) lost
time and motion due to the fact that errors caught at computer
validation must recycle through the entire process, and (4)
mechanical equipment being subject to greater wear than
electronic circuits.[30]

Key-to-disk or drum represents a significant improvement
in data entry equipment capability because of increases in
productivity due to the replacement of mechanical machine
functions with electronic circuits and the ability of its
small on-line computer to manipulate and validate data. Key-
to-disk or drum combines the best of the potentials of variable

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[30]Ibid., p. 12.

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length records, electronic speeds, and format control. Since
its use is new, it will be the topic of the remainder of this
chapter.

Most of the available literature on the subject of key-to-
disk or drum can be divided into two categories - one dealing
with hardware specifications, and the other with the results
experienced by companies that have installed the equipment.
The approach taken in the remainder of this chapter is similarly
divided.

The first task was to develop general and specific hardware
requirements based on the advice and recommendations offered
by private and Navy sources.[31] The requirements outline the
features that should be considered in comparing different
systems.

The second part of this chapter reports on the experiences
of a few Navy installations and private companies that have
utilized key-to-disk or drum equipment. The Naval Supply
Center at Newport, Rhode Island, has been the Navy's test site
for this type of equipment since 1970. Since 1971, the Naval
Supply Center at Oakland, California, has installed a system
and in September 1972, installations took place at the Naval

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[31]The specifications represent a composite of:
    (a)  EDP ANALYZER, Vol 9, No. 9, September 1971.
    (b)  EDP ANALYZER, Vol 9, No. 10, October 1971.
    (c)  Trimble, G. R. and Penta, A. J., "Evaluation of
        Keyboard Data Entry System," DATAMATION, June 1970,
        p. 93-99.
    (d)  Interview with CDR John Briggs, SC, USN, Director
        of Data Processing, Naval Supply Center, Long
        Beach, California, 17 July 1972.

Supply Centers at San Diego, Long Beach, and Puget Sound. In addition to reporting on what action the Navy has taken, a sampling of civilian industry experiences is offered in further support of the value of key-to-disk or drum systems.

A. HARDWARE REQUIREMENTS

1. General Hardware Description

a. Configuration

Each system is comprised of a processor, an immediate access storage device (disk or drum), a magnetic tape unit, a supervisory console, and keyboard entry stations, as shown in Table XIX on page 127.

b. Processor

The processor has sufficient speed, capacity and capability to simultaneously process all data entered from the key data entry stations connected to the system; to control all input, storage, and output devices including the supervisory console; and to perform data management operations.

c. Immediate Access Storage Device (Disk or Drum)

The on-line immediate access storage devices are available in a wide range of capacities. The device accumulates the data entered, displays the data for key verification, and permits selective pooling of output jobs onto the magnetic tape device. It may also be used to receive data from the tape device for further entry - a process called "turnaround." The immediate access storage device is not connected to the main frame computer system of the installation. The average

access time of the immediate access device is 150 milliseconds. The systems have warning indicators when the device is approaching capacity.

d.  Magnetic Tape Unit

The tape unit is capable of reading and writing standard 10 1/2-inch diameter, 2400-foot reels of computer-compatible tape at 800 bits per inch in either 7- or 9-track configuration. The drives move the tape during data transfer at a minimum of 20 inches per second. Immediate read-after-write checks with error indication and retry capability are provided.

2.  Specific Hardware Requirements

a.  Keystation

(1)  It should have a standard IBM 029 style, sixty-four character set layout.

(2)  It should display by non-hard-copy means at least the last character entered and preferably the entire record. Displays must be in English graphic.

(3)  The position indicator must be prominently displayed.

(4)  Position control features must permit backspace and forward space by character, by fields, and by record during either entry or verification.

(5)  The control switches must be convenient to operate but must preclude the likelihood of accidential operation.

(6) The keystation should consist of a desk-like structure with a surface for source documents (11" x 14"), keyboard, and display device.

(7) The system must be capable of both entry and verification at each station.

(8) The system must permit the start of verification by a second operator at another station anytime after 50 records have been entered.

(9) The system must be capable of correcting, deleting or adding records during entry or verification.

b.  Formatting

(1) The system must be capable of providing up to four record formats of variable length to the operator for continuous or cyclic use during a job.

(2) The system must be capable of accommodating a library of up to 200 different variable-length formats.

(3) Updating the format library must be possible via a pre-recorded program library tape and through the supervisor's console keyboard.

(4) The same or different formats must be available to all stations at the same time.

(5) The format must be in the 0 to 200+ character range with no limit on the number of fields per record.

(6) The format must provide for automatic and/or operator controlled duplication and skipping, blank fill, left zero fill, and left or right justification.

(7)  It is desirable that the device be capable of generating data for fields such as data or sequence number and cross-foot fields by adding, subtracting, dividing, or multiplying (i.e., extended price).

(8)  It is desirable that the device be capable of reformatting input data so that the input format can be different from the output format.

c.  Verification and Correction

(1)  The system must provide key verification with keyboard lock and light on error.

(2)  Verification must be possible by selected fields within records.

(3)  It is desirable that verification by sampling be provided.

(4)  The device must permit correction by back-spacing and rekeying one character, one field, or one record, with changes to all control totals being an automatic function of the system.

(5)  The system must provide a means for handling uncorrectable errors.

d.  Validation

(1)  The system must provide a limit or range-checking capability for any field against a stored value.

(2)  The system must be capable of accumulating batch totals on any field or set of fields, comparing these totals at job end with control totals entered by the operator

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from a source document, and giving verification if they do not agree.  Under verification, a zero balancing feature must be provided.

(3)  The system must be capable of character validation by comparing entry fields with entries pre-recorded in a table or its equivalent.

(4)  The system must accumulate and display at job end a record count of the number of records entered or verified.

(5)  The system should provide for field checks and mandatory entry and completion fields.

(6)  It is desirable that the system also provide range, value and/or total validation on the number of fields, length of fields, cross-field dependencies, and/or sequence checking.

(7)  The system must provide some method of modulo check digit capability.

e.  System and Software

(1)  The system must operate all stations simultaneously, using either the same or different program formats regardless of mode (entry or verify).  If one or more stations become inoperable, the other key stations must remain operational.

(2)  The system must be capable via a supervisory console, of initiating and transferring key entry data stored in immediate access storage to magnetic tape, or vice

versa (turnaround) without interrupting or degrading the performance and functions being accomplished at any of the key stations.

(3) The system must be capable of accommodating the interruption of a job at the end of a record within a batch, begin work on another job (the same or different format), and later resume keying on the former batch while maintaining all batch totals, production statistics, etc., separate.

(4) The system must permit a second operator to take over a job at the end of a record within a batch and complete the job while maintaining separate production statistics on each operator.

(5) All data transfers from or to main memory must be checked.

(6) The system must provide the capability of dumping data onto a "save tape" periodically during the work day, and on re-entering this tape to allow recapture of data that would have been lost in the event of equipment malfunction.

(7) The system must be able to control output tape blocking and header/trailer labels.

(8) The system must be capable of reformatting input data to meet output specifications.

(9) The system must be capable of locating a particular record using a 1 to 15 character search key and to have insertion/deletion capabilities with automatic control total and production statistic update.

(10)   The system must provide the supervisor with status information by job and by batch on command, as follows:

(a)   Keying started, suspended, not completed, not being keyed, and completed.

(b)   Verifying started, suspended, not completed, not being verified, and completed.

(c)   Transfer to tape started, cancelled, or completed.

(11)   The supervisor must be capable of accomplishing, via the supervisory console, the following:

(a)   Interrogate job and batch status.

(b)   Load, add, delete or change program record formats.

(c)   Initiate batch transfer of completed data from immediate access storage to magnetic tape.

(d)   Establish jobs and/or batches.

(e)   Delete records from the immediate access storage.

(f)   Request display of production statistics.

(g)   Receive system error messages if the system is not performing properly, such as disk error, non-recoverable tape error, etc., on a display device (hard copy or CRT).

(h)   Display all communications between the supervisor and the key entry system (hard copy or CRT).

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(i)  Initiate tape entry operation of turn-around document processing.

(12)  The system must provide the follc .ng production statistics by shift, operator, and job or a 24-hour basis via transfer to tape on supervisor command:

(a)  Start date.

(b)  Start time and stop time (or elapsed time).

(c)  Stop date.

(d)  Number of records.

(e)  Mode (data entry or data verify).

(f)  Number of errors, corrections and retries.

(g)  Number of actual keystrokes.

This concludes the listing of the requirements which should be considered when evaluating key-to-disk or drum systems.  The following section reports on the experiences of some Navy installations and private companies that have utilized key-to-disk or drum equipment.  Unfortunately, these experiences start with a system already selected and evaluate it against pre-viously used methods.  Therefore, the experiences are (especially in the Naval Supply Center, Newport, evaluation) cost/benefit studies of a given representative system without comparison of detailed differences in characteristics and features as would be undertaken in selection of a new system. Although the studies lacked selection criteria, sufficient information was presented to compare the effectiveness of new key-to-disk or drum systems with previous methods.

B. NAVY EXPERIENCES

   1. Navy Supply Center, Newport, Evaluation[32]

      a. General Information

         (1) Background. During the period December 1970
to March 1971, the Naval Supply Center, Newport, Rhode Island,
conducted an evaluation of a key-to-drum data entry system.
The system evaluated was the Key Edit Model 100 manufactured
by Consolidated Computer International, Inc., Toronto,
Canada. The test involved comparison of the Key Edit system
against conventional keypunch/verifier equipment and NCR-735
key-to-tape equipment. The center had considerable experience
with both types of machines. The systems were compared on
the basis of difficulty and duration of operator retraining,
operator productivity, accuracy of data preparation, system
reliability, and overall system costs.

         (2) Physical Configuration. The key Edit Model
100 is a computer controlled source data entry system in
which data is entered through keyboards onto a magnetic drum
storage unit. The data is subsequently transferred from the
drum to a magnetic tape in logical batches for further pro-
cessing on the main computer.

         The keyboards are similar to those used on
keypunch/verifer machines and on stand-alone key-to-tape machines.

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[32]Condensed from Kittock, K. E., LCDR, SC, USN.,
"Evaluation of Computer Controlled Source Data Entry Equip-
ment: Final Report," Naval Supply Center, Newport, Rhode
Island, April 1971, p. 1-45.

Each keyboard is capable of both entering and verifying data. NSC Newport has 12 keystations which replaced ten NCR-735's, three IBM 029's, and two IBM 059's. The Key Edit system can handle from 8 to 32 keystations.

Keystations are under the control of a mini-computer which provides time division multiplexing, i.e., time-sharing service, to each keyboard. The mini is a PDP-8 with a 12K core memory which is controlled by an operating system provided by the vendor. External control of the system (communication to and from the supervisor) is via a console teletype unit.

Intermediate storage capability is provided by a magnetic drum. Data is entered on the drum by the keyboards and is recalled from the drum by keyboards for verification. Drum layout is 128 tracks of seventy 80-character records each. Two tracks are required for program format storage and for portions of the operating system. Data capacity is therefore equal to 705,600 characters or 8820 card images. Larger drums are available.

Finished batches of input stored on the drum are transferred to magnetic tape by commands entered via the supervisor's console. The tape drive used is a 7-track, 556 BPI unit.

(3) <u>Software and System Operation</u>. The Key Edit system operates in an on-line and off-line mode. Data can be entered from all keyboards while the system is in the

on-line mode. All keyboards are locked out in the off-line mode.

The operating system is resident in the PDP-8 core memory while the system is operating in the on-line mode. It is loaded from the tape drive after a bootstrap loader is entered through the supervisor's console.

The operating system permits each operator to enter or verify data at electronic speed. As time-shared keyboards are substantially faster than the operator, she has the illusion of being on-line to the computer at all times. Program formats are entered onto the drum through the keyboard designated as logical keyboard 1. A maximum of 63 program formats can be stored; program formats are available to any keyboard by depressing the appropriate function key. A batch is identified by four alphanumeric characters. Batches may be opened, verified, and closed at any keyboard.

The operating system is constantly monitoring the status of the drum. The supervisor receives a warning on the supervisory console when the drum load reaches 94 tracks (32 tracks remaining). The warning is then repeated every four tracks. The operating system permits the supervisor to enter commands through the console to control key entry operations.

The only function which must be performed off-line (with keyboards inoperative) is dumping and restoring the drum. A drum dump is taken to preserve on magnetic tape

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the entire contents of the drum. This is a security feature which is employed to prevent the loss of source data entry work in the event of CPU or drum failure. It also ensures that a second copy of the data is available after a given batch has been released from the drum. The tape obtained from a drum dump is uniquely coded and not useful for subsequent processing. In the event this data is subsequently desired, it must be reloaded to the drum and then transferred to tape. Ten to fifteen minutes are required to dump a fully-loaded drum. NSC Newport is currently taking two drum dumps per day. The first dump is taken during the lunch hour, and the second is taken after the close of business. This schedule ensures that there is no loss of operator production manhours while the system is off-line.

b. Test Description

(1) Source Data Applications. The source documents employed in this evaluation are used in the Afloat Consumption Cost and Effectiveness Surveillance System (ACCESS) and the CSMP sub-system of the 3M system. The mix of source data employed in this evaluation is representative of the source data found in business-oriented data processing installations. These applications require alpha, numeric, and alphanumeric source data entry. They all require duplication of certain fields/characters, and some require left zero fill. Two of the primary source documents are the E&R and AR formats (NAVSUP 1250) which are conventional 80-column layouts.

(2) Operator and Supervisor Profiles. The operators selected for training on the Key Edit equipment are representative of the operators employed as NSC Newport. The profile of these operators is shown in Table XX. Nine of the ten operators had experience on the NCR-735 (employee #3532 is the operator who does not have such experience). However, employees #3385, #3532, and #3514 had been using 029/059 equipment for six months or more prior to the commencement of the Key Edit evaluation, while the other seven operators had been using NCR-735 key-to-tape units for six months or more prior to the commencement of the study. One of the supervisors was experienced in the operation of 029/059 and 735 equipment and the other had only IBM experience.

(3) Productivity Measurement. NSC Newport utilizes the Management Utilization and Control Standards Program, or MUACS, that was explained in Chapter VI, paragraph F. The production efficiency statistics based on six months' experience were available for the operators identified in the study. The approach employed by the study was to maintain the MUACS standard constant and observe any changes in individual production effectiveness that could be attributed to the new hardware.

(4) Reliability. The reliability of the Key Edit equipment was closely monitored throughout the evaluation. There are two general types of malfunctions which can occur

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with computer-controlled source data entry equipment. The
first type of malfunction involves only an individual key-
board. This type of malfunction occurred only once during
the evaluation and is not considered significant. The second
type is a malfunction in the central control unit. This type
of failure is extremely critical because all operators are
idle until repairs are effected.

The criterion for reliability was set out in
the GSA contract with Consolidated Computer International,
Inc., which stated: "All equipment furnished under this
contract shall perform the function for which it is intended
in accordance with the manufacturer's specifications and
other representations at an average effectiveness level of
90%."[33]

(5) Operator Accuracy. The error rates of all
keypunch operators are recorded and maintained by the data
processing department under the Zero Defects Program. Con-
sequently, a six-month mean error rate was available for each
operator for the period prior to the test. This rate was to
be compared with error rates recorded for the same operators
using the Key Edit equipment during the test.

c. Test Results

(1) Training. Operator training consisted of
four hours of individual keyboard instruction provided by

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[33]GSA Contract #GS-00S-84492, 1 July 1970 to June 1971.

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the vendor. This was augmented by periods of on-the-job training. It was determined that six to ten hours of this training were required for operators having recent key-to-tape experience and 12 to 16 hours were required for those operators with recent 029/059 experience. At the conclusion of the formal instruction and on-the-job training, the operators were capable of producing at a production and error rate acceptable to the data processing management of NSC Newport. Supervisors were trained in both keyboard (4 hours formal and 16 OJT) and system (8 hours formal and 12 OJT) operation. Management had been concerned about the ability of former key-punch supervisors to operate the mini-computer, but neither supervisor had any difficulty in mastering all control functions required. In summary, no significant problems were encountered in training either operating or supervisory personnel to handle the new equipment.

(2) Productivity. Table XXI and XXII show the production learning curve and data for the seven operators with recent NCR-735 experience. About one month was required for them to regain their previous mean production efficiency. From that point, productivity continued to rise over the remainder of the test period ending with a 12.2% mean pro-duction increase. Table XXIII shows the production learning curve for operators with recent 029/059 experience. About two months were required by these operators to regain their previous level of efficiency. Their production continued to

increase sharply after that point, ending the test period
at a 27% higher rate.  It should be noted that the curve
was still trending upward, so 27% is a conservative esti-
mate of the 029/059 operator productivity increase.  Table
XXIV compares the productivity of individual operators
previously using 029/059 equipment.

(3)  **System Reliability**.  System reliability
during the test period is summarized by Table XXV.  As is
shown, the percentage of "up" time averaged 95%, well within
the 90% specified in the GSA contract.  The overall re-
liability and performance of the Key Edit equipment was found
to be highly satisfactory.

(4)  **Operator Accuracy**.  Tables XXVI and XXVII
specify the error percentages achieved during the test by
previous NCR-735 and 029/059 operators respectively.  Both
groups showed initial increases in errors, but as they gained
proficiency with the Key Edit equipment, error rates were
reduced below pre-test levels.  A substantial portion of the
increased accuracy experienced was attributed to the capability
of the Key Edit equipment to display the last character
entered/verified directly.  The NCR units displayed a binary
pattern which required translation by the operator.  There
is, however, no current agreement among data processing
personnel regarding display of records.  Some argue to
display the entire record and others argue that the display

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of the entire record detracts the operator's attention and degrades performance.[34]

(5) <u>Cost Analysis</u>. The method used in LCDR Kittock's study was to reduce all costs associated with the Key Edit, NCR-735, and 029/059 equipment to an individual keyboard/worker basis. The volume of work that can be accomplished by one average operator with one keyboard during a given period of time is based on the productivity results already given and can be expressed by the following relationships:

1.27 029/059 keyboards equal one Key Edit keyboard,

1.12 NCR-735 keyboards equal one Key Edit keyboard. It was necessary to reduce the 029/059 keyboards to a composite keyboard since two separate keyboards are required to punch and to verify a given volume of work. Experience at NSC Newport indicates that the 029 keypunch is required approximately 60% of the time and the 059 keyverifier is re-quired approximately 40% of the time for a given volume of work.

The full range of operating costs for four data entry systems are shown in Table XXVIII. A detailed description of the cost analysis is presented in Table XXIX. All equipment rental and labor costs have been equated to the productivity levels previously mentioned; therefore, the

[34]EDP ANALYZER, Vol 9, No. 9, September 1971.

costs represent identical volumes of work for each system.
It should be noted that the significant costs associated
with the Key Edit system are the equipment rental, operators'
salaries, and fringe benefits.  The Key Edit system is cost
effective, even if all other costs are excluded from the
analysis.

(6)  Comments on the Newport Study.  One major
shortcoming of the NSC Newport evaluation is that all changes
in productivity were attributed to the new machinery.
Certainly the Hawthorne studies and the findings of the many
behavioral scientists discussed in Chapter IV have shown
that worker productivity is not solely a function of hardware
capabilities.  Some attempt should have been made to evaluate
the selected workers' attitudes before starting and before
ending the test.  Additionally, a control group, subjected
to the same management attention while performing the same
tasks on the old machinery, should have been used in com-
parison to the results of the test group in order to attempt
to isolate the productivity increases that could be attributed
to the new hardware.

2.  Naval Supply Center, Oakland, Study

In June 1971, the Naval Supply Center, Oakland, re-
quested from the Naval Supply Systems Command, installation
of a key-to-disk data entry system for processing of all
applications in support of tape-oriented computer systems.
Their previous equipment was all of the 029/059 variety.

They offered as justification: projected increases in productivity, lower costs, and enhanced data entry procedures. They did not wish complete replacement of keypunch/keyverify equipment due to certain applications which utilized an IBM 360/20 card-oriented computer.

The part of their operation recommended for conversion was composed of 160 procedures or formats with a monthly average of 600,000 records. This eligible group was divided into three categories of data entry effort, each requiring a different mode of operation in a key-disk environment. Group one consisted of typical keypunch procedures that could be entered normally into a key-disk system. Group two involved input that required batch-balancing to an accompanying adding machine tape. Group three, the most unique category, was composed of Supply Operations Assistance Program (SOAP) documents. Data was received in the form of prepunched cards that required alteration of some data and/or addition of new data.

NSC Oakland listed three major requirements and three desirable features for a key-disk system that would handle their applications. The major requirements were: the ability to accommodate the SOAP application in a cost-effective manner when compared to keypunch/keyverify systems, the ability to accumulate batch totals when processing fiscal data, and an intermediate storage capacity of 39,000 80-character records. The last requirement was quantified as

the result of a five-month study involving data entry requirements both in number and timing, and the costs associated with various amounts of storage. The three desirable features mentioned were: a dual system configuration, removable disk packs for intermediate storage, and a separate supervisory console. The dual system configuration (two 7-keystation systems instead of one 14-keystation system) was requested in order to provide additional flexibility by allowing various cross-connection schemes and to provide a hedge against the risk of processor or disk failure. Interestingly, two seven-station CMC-5 systems had a lower rental than one CMC-7 system with fourteen stations. A separate supervisory console for each system was desired because of the large number of formats and batches involved in each day's processing. Systems without separate consoles must be queried or directed through one of the keystations, thereby causing it to be totally pre-empted from production in Oakland's case. The removable disk pack feature was requested in order to gain flexibility in times of processor or equipment malfunction, or when high priority work overrides occur.

The cost-saving proposal submitted by NSC Oakland was based on a projected 25% increase in data entry activity. A revised proposal submitted in 1972 predicted yearly savings of $59,340 for the CMC equipment. Primary savings components were in hardware (26 IBM 029/059 machines replaced by a 14-keystation system), and in personnel (six fewer operators required).

3. Naval Supply Systems Command Current Procurement

Almost two years ago the Naval Supply Centers began requesting in earnest for key-to-disk or drum hardware. The results of the Newport study had become known, and interesting tales of significant gains were being reported in the trade journals.[35] The Naval Supply Systems Command in Washington, D. C., honored the request of NSC Oakland, but held the others in abeyance until a consolidated request could be drawn and the results of Newport and Oakland studied in greater detail.

A solicitation of proposals is currently being prepared for issue in September 1972. On the basis of this solicitation, a single hardware manufacturer will be selected and hardware installed at all tidewater supply centers and inventory control points. In the interim, permission has been granted to the west coast tidewater supply centers to install CMC-7 systems.

C. CIVILIAN CORPORATE EXPERIENCES

1. Bonus Gifts Incorporated[36]

Bonus Gifts, Incorporated is a firm involved in the redemption of coupons carried on some 500 grocery products.

Their old system involved twelve IBM 2260 CRT terminals on line to an IBM 360/50. They decided to install a Redcor

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[35]See DATAMATION, June 1970.

[36]EDP ANALYZER, Vol. 9, No. 10, October 1971, p. 1.

Key Logic key-to-disk system with ten stations. The main reason for the change was a desire for an offline system independent of CPU availability. They also hoped for increased accuracy due to the Key Logic's edit capabilities.

The results of the conversion were impressive. In the first six months of operation, average operator productivity increased 25%. Operator requirements decreased from 8 to 10 full-time people to 6 to 8, and average productivity went from between 12,000 and 15,000 average keystrokes per hour to between 15,000 and 18,000. The error rate fell from over 5% to about 1/2%.

The Key Logic processor has been programmed to perform a number of validity checks. It rejects alpha characters in designated numeric fields. It checks to see if a field value is one of a specified set or within a pre-determined range. It also performs check digit validation and control total balancing. Because of these automatic validation capabilities, Bonus Gifts has found that key verification is required on only one field of each record type.

2. Xerox Data Systems[37]

Xerox Data Systems is the computer manufacturing division of Xerox Corporation. The company set three goals to be met by a new data entry system:

    a. Higher productivity per operator,

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[37]Ibid., p. 2.

b. Ability to handle an increasing workload and at a reduced data conversion cycle time, and

c. Easy retraining requirements.

They selected a CMC-9 Key Processing System because they were able to contact six users of the system, all of whom were pleased with it, because the system provided a large 7 1/4 million character) disk storage, and because other users' experience indicated a retraining time of about two days was required to make operators productive. They ordered a system having 15 keystations and one supervisor station to replace 17 keypunches and verifiers. They would have had to add more keypunches and hire more operators due to the increasing workload had they not converted to the CMC-9. In an eight-month period, the system was down twice - once for twenty minutes and once for an hour. Their error rate went from 2% to below 1%, some weeks being virtually error free. A productivity increase of 24% for an average operator on an average job was realized. They have experienced 25% to 40% less turnover of operators leaving with no reason.

3. Columbia Broadcasting System[38]

A regional data processing center of the Columbia Broadcasting System in Hollywood, California, recently replaced a two-site operation totaling nine keypunches and six verifiers with a six-station Inforex system at a single location. Their operator requirements were reduced from ten

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[38]Ibid., p.

to eight.  Input equipment rental costs were reduced by 10%
and both floor space and supply costs went down.  Production
rates went from an average of 10,000 keystrokes per hour to
13,000.  CBS is planning to do batch proofing and file main-
tenance on the system to reduce main computer time.

4.  Blue Cross[39]

A much larger operation was converted at Blue Cross
of Southern California.  They converted from an NCR-735 key-
to-tape system to a 60-station CMC-9 key-to-disk operation.
One of the biggest advantages to Blue Cross involved the
limited verification feature.  They redesigned their record
formats incorporating some of up to 480 characters which
greatly simplified procedures.  With the Key Processing system,
any individual field may be selected for verification.  They
recorded productivity increases of 15% to 20% over the tape
units.  Although keying speeds remained about constant, re-
duced time in tape handling and program loading accounted for
the increased productivity.  Elimination of pooling needed
for consolidation of like records for submission to the
computer equipment resulted in $2500 per month savings and
10% savings on other hardware.  Operator requirements were
lowered by five, and it is anticipated that fewer operators
and supervisors will be required to handle an increasing
workload.  Retraining times for operators was one day, and

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[39]Landon, J. R., "Data Preparation at Blue Cross,"
DATAMATION, June, 1970, p. 91-92.

they returned to previous output levels in one to one and one-half days as opposed to the one month time period required by such operators at NSC Newport. A 98.3% hardware reliability has been recorded.

## D. CONCLUSIONS

The requirements of individual installations vary depending on the type of data being entered and the peripheral hardware on the installations' computers. These influences must be considered in any selection process. Keypunch/keyverify equipment or buffered card equipment is most efficient if the volume is low, cards are required, and/or operators are decentralized. Key-to-tape may be preferred in such an environment if the volume is higher or if variable record lengths are required. Key-to-disk or drum is most efficient in high volume, batch-entry operations where the data entry process is centralized. If a few jobs remain that require cards, a cost analysis should be performed to determine if it would be less expensive to retain standard punch/verify machines, to utilize key-to-tape or key-to-disk or drum equipment and have the main computer punch the required cards, or to obtain an optional card punch unit for use with a key-to-disk or drum system. The peripheral hardware of the CPU must also be investigated to ensure that it will accept the entry unit output without intermediate modifications. A comparison of various available entry hardware is presented in Table XXX.

One major advantage of key-to-disk or drum hardware that
has not been fully developed is the potential of the equip-
ment to restructure the workl.ad by performing data validation.
The power of the mini-computer to perform operations such as
table look-up, range checking, field continuity, cross
referencing, etc. offers to data processing management the
ability to shift these time-consuming tasks from the expensive,
over-burdened main frame.

It appears that shared processor keyboard data entry
systems are a cost-effective possibility for many data
processing installations.  With the use of this equipment in
these installations, the result should be an increase in the
marginal physical product of keypunch machinery.
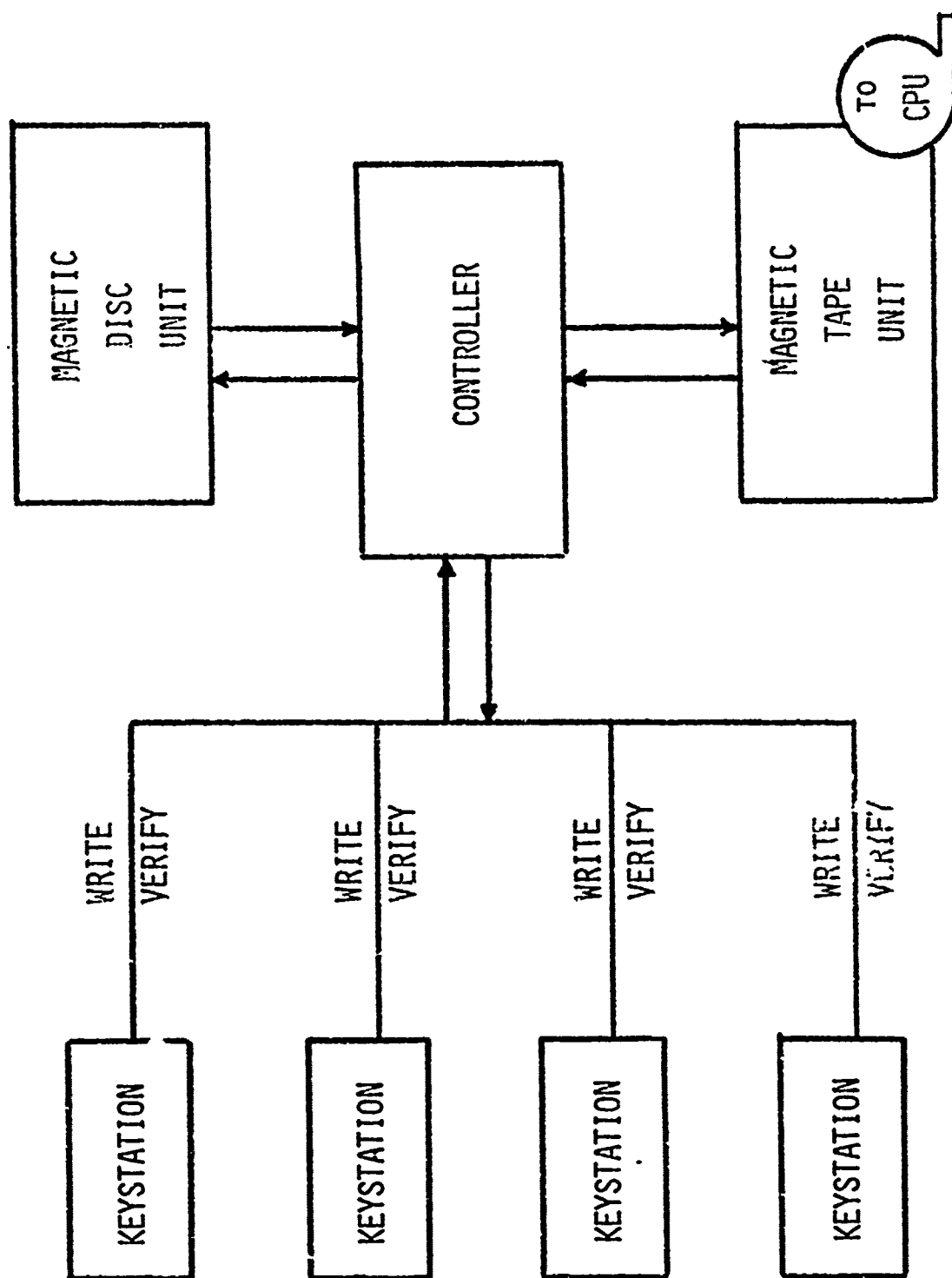
TABLE XIX

TYPICAL SYSTEM CONFIGURATION

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## TABLE XX

## PROFILE OF OPERATORS ASSIGNED TO KEY EDIT EVALUATION

| EMP. NO. | AGE | PREVIOUS EXPERIENCE (YRS) 029/059 | NCR 735 | MOST RECENT EXPERIENCE |
|---|---|---|---|---|
| 2531 | 24 | 1.0 | 3.5 | NCR 735 |
| 3333 | 28 | 0.3 | 2.5 | NCR 735 |
| 3279 | 23 | 3.0 | 1.0 | NCR 735 |
| 3520 | 22 | 1.5 | 0.25 | NCR 735 |
| 3328 | 41 | 2.5 | 1.0 | NCR 735 |
| 3383 | 21 | 2.0 | 1.5 | NCR 735 |
| 2950 | 20 | 1.0 | 1.0 | NCR 735 |
| 3385 | 21 | 0.5 | 1.5 | 029/059 |
| 3532 | 19 | 1.75 | -0- | C29/059 |
| 3514 | 22 | 4.25 | 0.25 | 029/059 |
| | | | | |
| MEAN | 24 | 1.78 | 1.25 | |

## TABLE XXI

### PRODUCTION LEARNING CURVE

### OPERATORS PREVIOUSLY USING NCR 735 EQUIPMENT
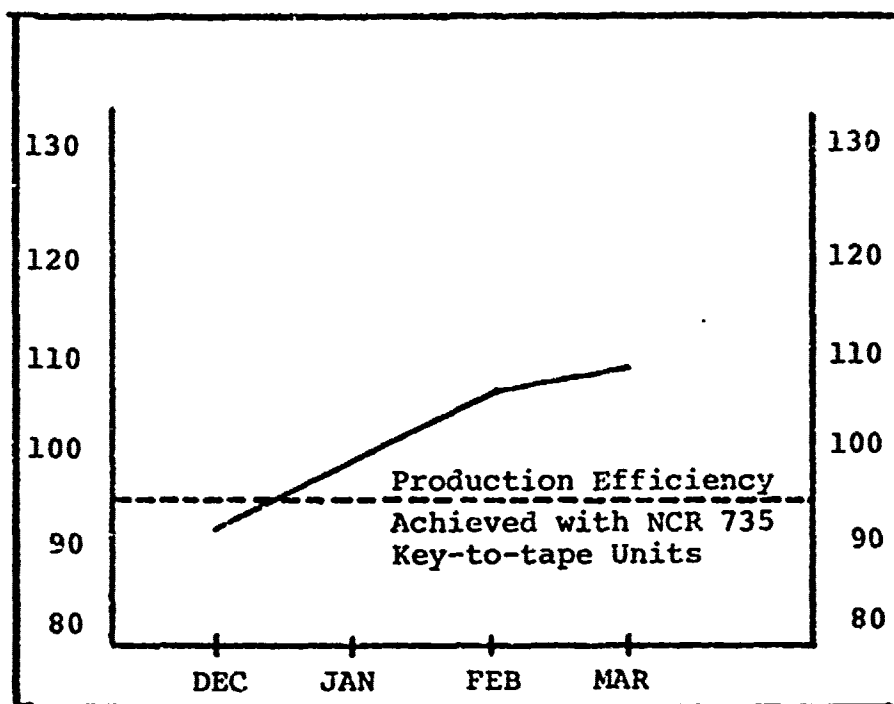
## TABLE XXII

### PRODUCTIVITY OF OPERATORS PREVIOUSLY USING NCR 735

| EMP. NO. | NCR 735 MEAN 1/PROD. EFF. | KEY EDIT MEAN 2/PROD. EFF. | % INCREASE (DECREASE) |
|---|---|---|---|
| 2950 | 102.8 | 122.4 | 19.0 |
| 3520 | 75.7 | 91.8 | 21.2 |
| 3383 | 98.9 | 106.5 | 7.6 |
| 2531 | 107.0 | 106.8 | 0.0 |
| 3333 | 88.1 | 105.1 | 19.2 |
| 3328 | 99.8 | 109.5 | 9.7 |
| 3279 | 91.0 | 101.9 | 11.9 |
| | | | |
| MEAN | 94.6 | 106.2 | 12.2 |

1/  BASED ON MAY-OCT 1970 PRODUCTION RECORD

2/  BASED ON FEB-MAR 1971 PRODUCTION RECORD

# TABLE XXIII

## PRODUCTION LEARNING CURVE

## OPERATORS PREVIOUSLY USING 029/059 EQUIPMENT
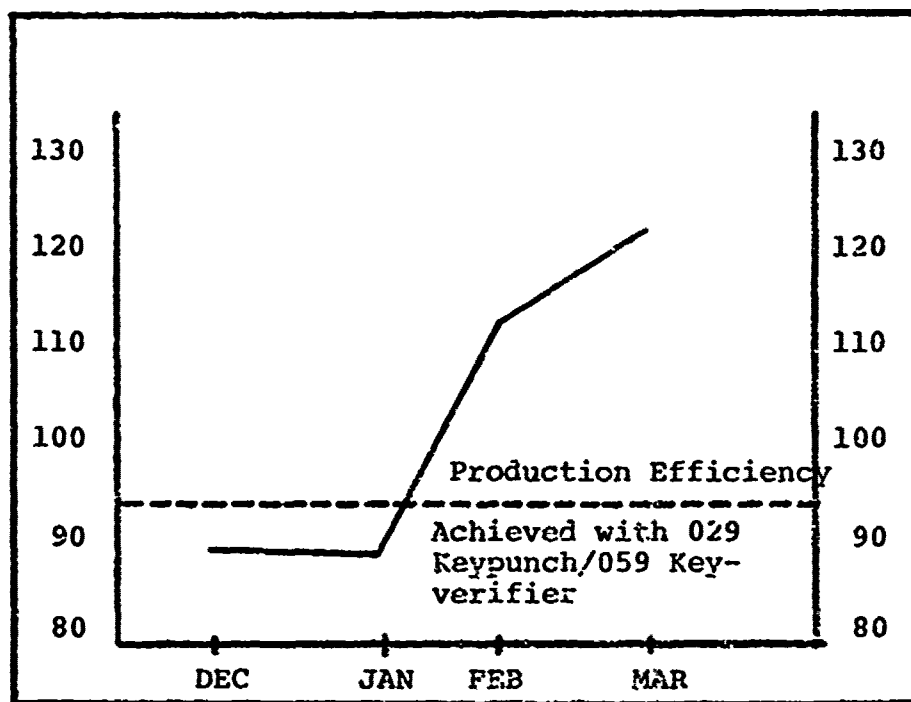
## TABLE XXIV

### PRODUCTIVITY OF OPERATORS PREVIOUSLY USING 029/059

| EMP. NO. | 029/059 MEAN 1/PROD. EFF. | KEY EDIT MEAN 2/PROD. EFF. | % INCREASE (DECREASE) |
|----------|---------------------------|---------------------------|-----------------------|
| 3814 | 108.7 | 129.1 | 18.7 |
| 3385 | 83.1 | 108.3 | 30.3 |
| 3532 | 82.9 | 113.3 | 36.6 |
| MEAN | 92.0 | 116.9 | 27.0 |

1/ BASED ON MAY-OCT 1970 PRODUCTION RECORD

2/ BASED ON FEB-MAR 1971 PRODUCTION RECORD

## TABLE XXV

### SYSTEM RELIABILITY

| MON | SCHEDULED HOURS* | PRODUCTIVE HOURS | DOWNTIME HOURS | % EFFEC- TIVENESS |
|-----|------------------|------------------|----------------|-------------------|
| DEC | 187.0 | 178.0 | 9.0 | 95.2 |
| JAN | 170.0 | 156.7 | 13.3 | 92.1 |
| FEB | 161.5 | 152.5 | 9.0 | 94.4 |
| MAR | 195.5 | 190.5 | 5.0 | 97.5 |
| AVG. | 178.5 | 169.4 | 9.1 | 94.8 |

*The scheduled hours are based on a system availability of 8.5 hours a day, 5 days a week.

## TABLE XXVI

### ERROR RATES
### (PERCENT)
### OPERATORS PREVIOUSLY USING NCR 735

| EMP. NO. | 1/NCR 735 (6 MO MEAN) | DEC | KEY EDIT EQUIPMENT | | |
|---|---|---|---|---|---|
| | | | JAN | FEB | MAR |
| 2950 | 0.7 | 1.2 | 1.0 | 0.6 | 0.7 |
| 3520 | 1.7 | 3.3 | 2.8 | 2.0 | 1.6 |
| 3383 | 2.1 | 3.0 | 2.5 | 1.7 | 1.3 |
| 2531 | 2.4 | 3.9 | 2.2 | 1.6 | 2.0 |
| 3333 | 1.5 | 2.3 | 2.1 | 1.4 | 1.2 |
| 3328 | 1.6 | 2.3 | 1.9 | 1.3 | 1.2 |
| 3279 | 2.0 | 1.9 | 1.9 | 1.6 | 1.3 |
| MEAN | 1.6 | 2.6 | 2.1 | 1.5 | 1.3 |

1/ MEAN BASED ON MAY-OCT 1970 ERROR RATES

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## TABLE XXVII

### ERROR RATES
(PERCENT)
OPERATORS PREVIOUSLY USING 029/059 KEY ENTRY UNITS

| EMP. NO. | 029/059 (6 MO MEAN) | DEC | KEY EDIT EQUIPMENT | | |
| --- | --- | --- | --- | --- | --- |
| | | | JAN | FEB | MAR |
| 3514 | 1.7 | 3.1 | 1.6 | 1.6 | 1.5 |
| 3385 | 2.0 | 2.8 | 2.4 | 1.8 | 1.6 |
| 3532 | 6.4 | 5.4 | 3.7 | 2.8 | 2.1 |
| | | | | | |
| MEAN | 3.4 | 3.8 | 2.6 | 2.1 | 1.7 |

## TABLE XXVIII

### OPERATING COST PER KEYBOARD PER MONTH

|  | 029/059 | NCR 735 | 1/KEY EDIT 12 KB | 2/KEY EDIT 20 KB |
|---|---|---|---|---|
| EQUIPMENT RENTAL | $110 | $171 | $153 | $114 |
| SALARY GS-3/1 | 584 | 516 | 460 | 460 |
| FRINGE 10% | 58 | 52 | 46 | 46 |
| SUB-TOTAL | $752 | $739 | $659 | $620 |
| PUNCH CARDS | $ 24 | | | |
| CARD SALVAGE | (4) | | | |
| CARD TO TAPE | 12 | | | |
| EDITING/POOLING AT 200 BPI | | $ 37 | | |
| EDITING AT 556 BPI | | | $ 4 | $ 4 |
| CONTRCL UNIT DOWNTIME | | | 25 | 25 |
| SUBTOTAL | $ 32 | $ 37 | $ 29 | $ 29 |
| TOTAL............ | $784 | $776 | $688 | $649 |

1/ KEY EDIT SYSTEM 100/100 WITH 716,800 CHARACTER DRUM
(CURRENT INSTALLATION)

2/ KEY EDIT SYSTEM 100/85 WITH 1,427,600 CHARACTER DRUM

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# TABLE XXIX

## FORMULATION OF MONTHLY OPERATING COSTS

1. 029/059

    a. Equipment Rental

    For a given volume of work, the 029 is required 60%
    of the time and the 059 is required 40% of the time.
    Cost of composite 029/059 keyboard is 0.6 x 85 + 0.4 x
    89 = $86.60.  Cost of composite keyboard adjusted to
    Key Edit productivity (throughput) level is $86.60 x
    1.27 = $109.98.

    NOTE:  IBM charges extra shift rental on this equip-
    ment.  This increases the cost by 10% of 1/176th
    of the basic monthly rental for each hour over 176
    hours that the average machine is used during the
    month.

    b. Salary

    GS-3/1 at $460 per month adjusted to Key Edit pro-
    ductivity (throughput) level is $460 x 1.27 = $584.20.

    c. Fringe Benefits

    10% Fringe is .10 x $584.20 = $58.42.

    d. Punch Cards

    Mean cards punched/verified per keyboard (based on
    March 1970 production) is 24,200.  Mean cost per 1000
    cards is $1.00.  Punch card cost is 24.2 x $1.00 =
    $24.20.

TABLE XXIX (CONT)

e. Card Salvage

Card salvage value is $.04 per pound, 24,200 cards weigh 96.8 pounds.

Card salvage is 96.8 x $.04 = $3.87.

f. Card-to-Tape Cost

Effective card read speed is 450 cards per minute.

Time required to read cards produced by one 029/059 keyboard is $\frac{24,200}{450}$ = 54 minutes.

Out-of-pocket costs associated with government-owned 1401 components required for card-to-type operation is $13.50 per hour.

Card-to-tape cost is $\frac{54}{60}$ x $13.50 = $12.15.

NOTE: These costs may not be valid if cards are input directly to the main computer. However, except in the case of very low volume, the main CPU time would be more costly than card-to-tape conversion.

2. NCR 735

a. Equipment Rental

Keyboard rental is $152.

Cost of keyboard adjusted to Key Edit productivity (throughput) level is $152 x 1.122 = $170.54.

NOTE: There is no extra shift rental for this equipment.

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TABLE XXIX (CONT)

b. Salary

GS-3/1 at $460 per month adjusted to Key Edit productivity (throughput) level is $460 x 1.122 = $516.12.

c. Fringe Benefits

10% Fringe is .10 x $516 = $51.60.

d. Editing/Pooling at 200 BPI

UNIVAC 1500 cost is $14.75 per hour.

1.75 hours required for pooling.

0.75 hours required for editing.

Editing/Pooling cost is 2.50 x $14.75 = $36.87.

3. Key Edit 12-Keyboard Configuration

a. Equipment Rental

Monthly rental for Key Edit 100/100 system with 716,800 character drum is $1840.

Keyboard unit cost is $\frac{$1840}{12}$ = $153.33.

NOTE: There is no extra shift rental for this equipment.

b. Salary

GS-3/1 is $460 per month.

c. Fringe Benefits

10% Fringe is .10 x $460 - $46.00.

TABLE XXIX (CONT)

d.  Editing at 556 BPI

UNIVAC 1500 cost is $14.75 per hour.

0.25 hours required for editing.

Editing cost is 0.25 x $14.75 = $3.69.

e.  Control Unit Downtime

$2.70 per operator/hour x 9.1 hours/mo. = $25.00.

4.  Key Edit 20-Keyboard Configuration

a.  Equipment Rental

Monthly rental for Key Edit 100/85 system with

1,427,600 character drum is $2280.

Keyboard unit cost is $\frac{\$2280}{20}$ = $114.

NOTE:  There is no extra shift rental for this

equipment.

b.  Salary

GS-3/1 is $460 per month.

c.  Fringe Benefits

10% Fringe is .10 x $460 = $46.00.

d.  Editing at 556 BPI

UNIVAC 1500 cost is $14.75 per hour.

0.25 hours are required for editing.

Editing cost is 0.25 x $14.75 - $3.69.

e.  Control Unit Downtime

$2.70 per operator/hour x 9.1 hours/month = $25.00.

| TRADE NAME | MANUFACTURER | FULL TRADE NAME | CHARACTERISTICS OF DATA | | |
|---|---|---|---|---|---|
| | | | CHAR-ACTER RANGE | MAX CHAR PER FIELD | MAX FIELDS PER RECORD |
| CMC-9 | COMPUTER MACHINERY CORPORATION | KEYPROCESSING SYSTEM MODEL 9 | 1-240 | 64 | 32 |
| KEY-EDIT | CONSOLIDATED COMPUTER | KEY-EDIT SERIES 100 | 20-240 | RECORD SIZE | RECORD SIZE |
| DATA-TAPE 2100 | GENERAL COM-PUTER SYSTEMS INC. | DATA-TAPE 2100 | 1-200 | 50 | |
| KEYPLEX | HONEYWELL DATA PRODUCTS DIVISION | KEYPLEX | 1-400 | 400 | 400 |
| INFOREX | INFOREX, INC. | INFOREX KEY ENTRY STATION 2901 Keystation 1301 Control Unit | 16-125 | 125 | 125 |
| LC-720 KeyDisc | LOGIC CORPORATION | LC-720 KeyDisc System | 1-160 | RECORD SIZE | RECORD SIZE |
| Key-Logic | PENTA COMPUTER ASSOCIATES, INC. | KeyLogic | 14-400 | 200 | 57 |

COMPARATIVE TABLE OF KEY-TO-DISK SYSTEMS

TABLE XXX

| TRADE NAME | EDITING | | NUMBER OF STD FORMATS | KEYBOARD | | DISPLAY | | PROCESSOR | |
|---|---|---|---|---|---|---|---|---|---|
| | BEFORE RELEASE | AFTER RECORDING | | IBM 029 COMPAT | TYPE | FORM | DISPLAY NR CHAR | PROGRAMMABLE | OPERATOR CHANGE |
| CMC-9 | YES | YES | 300 | YES | SOLID-STATE | ALPHA-NUMERIC | 1 | YES | NO |
| KEY-EDIT | YES | YES | 63 | YES | SOLID-STATE | ALPHA-NUMERIC | 1 | YES | YES |
| DATA-TAPE 2100 | YES | YES | none | YES | | STRIP PRINTER | 1 ALPHA AND 9 NUMERIC | | |
| KEYPLEX | YES | YES | 400 | YES | | ALPHA-NUMERIC | 1-4 | YES | |
| INFOREX | YES | YES | 4 | YES | SOLID-STATE | ALPHA-NUMERIC | 125 | NO (BY MFGR ONLY) | NO |
| LC-720 KeyDisc | YES | YES | 1000 | YES | SOLID-STATE | ALPHA-NUMERIC | 1 (optional crt-240) | YES | YES |
| KeyLogic | YES | YES | 200 + 1000 on tape | YES | IBM 029 | ALPHA-NUMERIC | 1 | YES | NO |

COMPARATIVE TABLE OF KEY-TO-DISK SYSTEMS

TABLE XXX

| TRADE NAME | OUTPUT MEDIA | | | | | OPTIONS | COSTS | | |
|---|---|---|---|---|---|---|---|---|---|
| | COMPUTER FORMAT | NR OF TRACKS | REEL SIZE | BPI | IBM COMPAT | | PURCHASE | MAINTENANCE | RENTAL PER MONTH |
| CMC-9 | CHAR SERIAL ASCII EBCDIC | 7 | 10.5 | 556 800 | YES | | $98,000 10 stations | $336. | $2,225 |
| KEY-EDIT | CHAR SERIAL ASCII EBCDIC | 7 9 | 10.5 | 556 800 | YES | CARD PUNCH PRINTER | $87,000 to $131,700 | $400 to $630 | $1,660 to $2,510 |
| DATA-TAPE 2100 | CHAR SERIAL | 7 9 | 10.5 | 200 556 800 1600 | YES | | $155,000 | | $4,250 |
| KEYPLEX | CHAR SERIAL ASCII EBCDIC | 7 9 | | 556 800 | YES | | $150,000 | | $2,800 to $3,800 |
| INFOREX | CHAR SERIAL ASCII EBCDIC | 7 9 | 8.5 | 556 800 | YES | | $25,000 processor $1,200 station | $50 processor $4 station | $560 processor $50 station |
| LC-720 KeyDisc | CHAR SERIAL ASCII EBCDIC | 7 9 | 10.5 | 200 556 800 1600 | YES | PAPER TAPE CARD PUNCH | $150,000 | $510 14 stations | $2,500 |
| KeyLogic | CHAR SERIAL ASCII EBCDIC | 7 9 | 10.5 | 556 800 | YES | PAPER TAPE CARD PUNCH | $110,000 | $375 | $3,000 |

COMPARATIVE TABLE OF KEY-TO-DISK SYSTEMS

TABLE XXX

| TRADE NAME | KEYSTATIONS | | INTERMEDIATE ACCESS STORAGE DEVICE | | |
| --- | --- | --- | --- | --- | --- |
| | NUMBER | SUPER-VISOR | CAPACITY | RECORDS | DEVICE |
| CMC-9 | 10-32 | ASR-33 | 7.25M CHARACTERS | 56,099 | DISC 12.5ms avg. latency 80ms seek time |
| KEY-EDIT | 8-32 | ASR-33 | .7M-5.6M Char. | 8,820-70,560 | DRUM 17ms avg. access time |
| DATA-TAPE 2100 | 19-31 | STD GCS KEYBRD & PRINT TERMINAL | 850K CHARACTERS | | FIXED HEAD DISC |
| KEYPLEX | 8-64 | ASR-33 | 3.5M CHARACTERS | | DISC |
| INFOREX | 8-16 | ANY STATION | 688K CHARACTERS | 5,500 125 CHAR LONG | DISC |
| LC-720 KeyDisc | 12-64 | ASR-33 | 7.25M or 29 M CHARACTERS | 40,000-160,000 | IBM 2311 |
| KeyLogic | 8-64 | IBM Selectric | 2M CHARACTERS | 106,000 | FIXED HEAD DISC 17ms Avg. access time |

COMPARATIVE TABLE OF KEY TO DISK SYSTEMS

TABLE XXX

# VIII.   COST ANALYSIS

The recommendations of the previous chapters will yield
benefits in increased productivity in terms of increased
marginal physical product of labor and machinery, but re-
calling from Chapter I:

$$\text{Marginal Cost} = \frac{\text{Price Per Unit of Labor}}{\text{Marginal Physical Product of Labor}}$$

If the price per unit of labor (or machinery) increases
proportionally with the increase in marginal physical product,
no cost saving will result.  One objective, therefore, should
be to restrain the increase in the price per unit of labor
(or machinery) so that it is proportionately less than the
increase in marginal physical product of labor (or machinery).
Even though there are many variables that are installation
dependent, such as the savings generated by reducing the
error rate on procedure XXX from 3% to 1%, major machine cost
elements can be identified and projected based on previous
experience with various hardware configurations.  Additionally,
if the probability of a worker falling below or exceeding the
average installation productivity level is normally distributed
about the average production level of the installation, the
cost behavior of the proposed incentive plan can be developed.

Greenblatt (1972), in a comparative analysis of various
types of keyboard entry systems, offers a projection of labor
costs and equipment costs that are shown in Table XXXI and
XXXII.  While it may be argued that wages vary from one

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TABLE XXXI

## DATA ENTRY LABOR COSTS
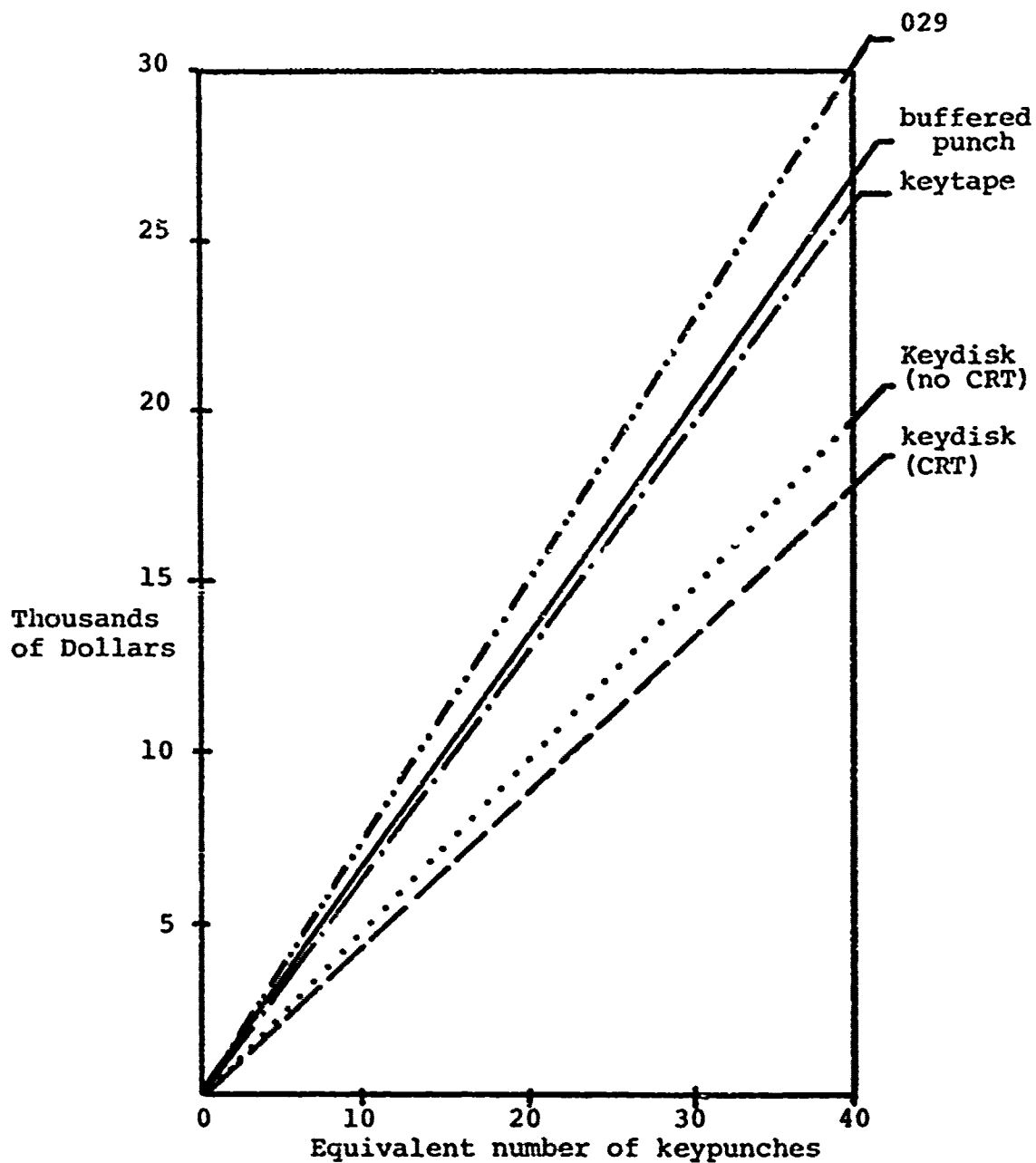


Source: Greenblatt, S., "Delete Delays and Dollars with Direct Data Entry," INFOSYSTEMS, September, 1972, p. 21.

# TABLE XXXII

## MONTHLY EQUIPMENT COSTS

geographical area to another, what is important to observe in Table XXXI is not the slopes of the cost lines, but, rather, the slopes in proportion to each other. The relation of the slopes is due to observed productivity (throughput) differences in the machines. The cost lines presented in Table XXXII, however, are subject to individual fluctuations as equipment manufacturers modify their prices. Currently, key-to-disk or drum systems first become economically competitive with key-to-tape and buffered punches at about 6 machines. It should be noted, however, that Greenblatt's (1972) costs are average costs, and that because of the wide range in prices for key-to-disk hardware, many systems are available that have an economic advantage such as was discussed in the NSC Newport study in Chapter VII and Tables XXVIII and XXIX.

The average level of productivity is represented by the formula in Table VIII which determines an average for a particular job on the basis of the predetermined Procedure Time Model and observed production. Assuming that operator productivity on any one job is distributed about a mean productivity level that is approximated by the calculated average, the installation's productivity on the total population of jobs can be shown via the Central Limit Theorem to be normally distributed about the mean or average pro- ductivity level of the installation. This distribution is shown in Table XXXIII in several forms to indicate the effect the variance has on the shape of the distribution. The

# TABLE XXXIII

## DISTRIBUTION OF PRODUCTION EFFICIENCY



mean
performance     A

100%     115%

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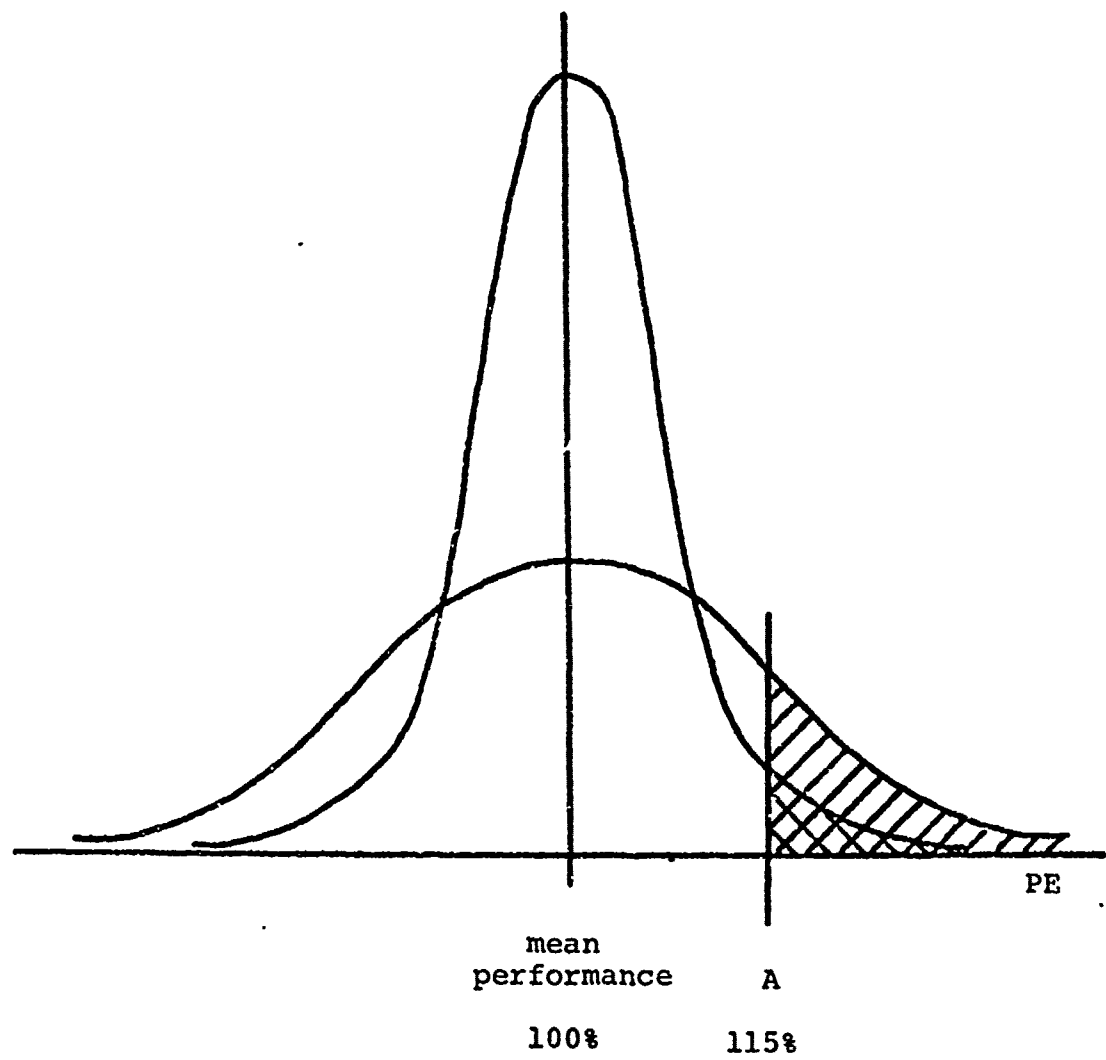
variance is a measure of the frequency and distance individual performances fall from the average.  If there is a great difference between the individual performances of the installation's operators, the distribution will be flat and spread out.  If the individual operators are very similar in their performance, the distribution will be tall and thin. If the average represents a 100% production efficiency level and point A in Table XXXIII represents 115% production efficiency, the probability of an operator performing at 115% or more may be considered as being represented by the shaded area under the curve.  In the tall curve this area is small and thus the probability is small.  In the flat curve the area is larger and the probability is larger.  The spread of operator performance can not be predicted in this thesis because no actual keypunch installation is being considered; since the spread of operator performance determines the probability of an operator exceeding the average productivity level of the installation, no actual system cost can be derived at this time.

· One other major factor in the probability of an operator receiving an incentive reward is the placement by management of the Incentive Base described in Chapter VI and shown in Table XVI.  If the incentive base is set at 100%, as shown by point B in Table XXXIV(a), then the probability of an operator performing at 100% production efficiency or more is 50%.  If the incentive base is set at 90%, represented by

# TABLE XXXIV

## EFFECT OF THE INCENTIVE BASE



(a)

50%

B
100%

PE

(b)

84%

C
90%

100%

PE
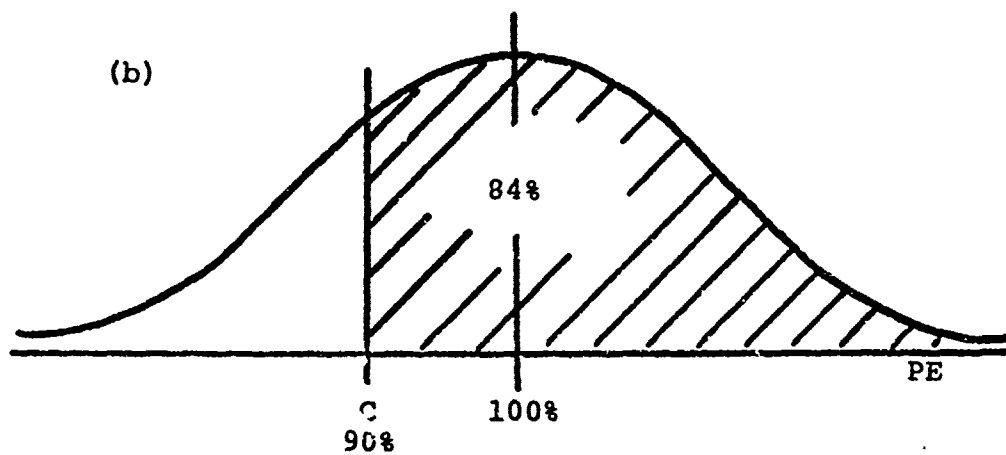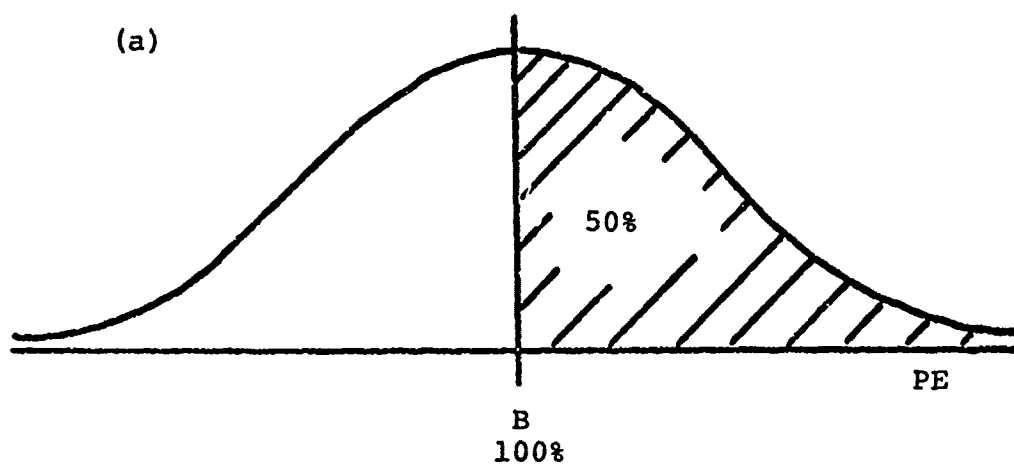
point C in Table XXXIV(b), and if 90% is one standard
deviation from 100%, the probability of an operator performing
at 90% or more and earning an incentive award is 84%. As
the probability of an operator earning an incentive reward
increases, more operators will earn more money causing an
increase in the price per unit of labor and a decrease in
the overall cost savings.

In summary, the goal is to proportionally increase the
marginal physical product of labor and machinery more than
their respective unit costs. No exact dollar costs can be
derived at this time since no specific keypunch installation
is being considered. Given a specific installation, a cost
analysis could be performed based on hardware replacement,
environmental improvements required, and a measure of the
variance in operator production ability.

## IX.  CONCLUSION

The responsibility for civilian incentive plans within the Navy has been assigned to the Director of Civilian Manpower Management.  The Director is authorized to establish the policies and standards concerning incentive awards and to  grant approval to exception requests.  He has assigned the responsibility and authority for incentive awa·d promotion and administration to the Head of the Motivation and Incentives Branch, Office of Civilian Manpower Management.

The purpose of the civilian incentive program is, first, "to encourage employees to participate in improving the efficiency and economy of Government operations," second, "to recognize and reward employees, individually or in groups, for their suggestions, inventions, superior accomplishments, or other improvement in Government operations," and, third, "to recognize and reward employees, individually or in groups, who perform special acts or services in the public interest in connection with, or related to, their employment."[40]  The incentive plan offered by this thesis is intended to recognize and reward the individual keypunch employee for her superior accomplishment in Government operations.  Specifically, the incentive will be granted on the basis of individual performance contribution that meets the Government established

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[40]Federal Personnel Manual, Chapter 451, Paragraph 1.2.

standards of: "performance of assigned duties, with special effort or special innovation, that results in significant economies or other highly desirable benefits," or "performance of assigned tasks so that one or more important job requirements is significantly exceeded."[41]

The value of the awards presently authorized for contributions of a performance nature range from $100 to $150 per year for employees in the keypunch grade levels. For contributions of a one-time beneficial suggestion nature, the award is in the range of 10% of the anticipated annual savings that would result from implementation of the suggestion. The incentive award offered by this thesis is based on a percentage of the savings generated by the measured and documented increased productivity of the keypunch operator. The actual percentage used can be adjusted to permit competitive bidding for labor hours in the labor markets of various geographical areas.

The government incentive plan urges "prompt action on contributions to encourage maximum employee participation and obtain all possible benefits to the Government."[42] The period of measurement of the incentive plan offered by this thesis coincides with the two-week pay period for federal civilian employees. The incentive award is paid in the paycheck

[41]Ibid., Paragraph 3.2c.3 and 4.

[42]Ibid., Paragraph 2.4.

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immediately following the period of measurement on the premise that any greater separation will disorient the payment from the effort that earned the award.

Unlike financial incentive rewards, improvements in the physical environment of the workspace may not foster an increase in worker productivity, but they may ensure that working conditions do not inhibit the motivational and technological recommendations of this thesis. Workspace improvements provide a relatively inexpensive method for data processing management to initially solicit operator participation in what happens in the keypunch installation. The experience of Naval Supply Center, Long Beach, California, was that when the keypunch operators were invited to participate in decisions regarding workspace improvements, their reaction was enthusiastic and they readily adopted the general conservative guidelines suggested by data processing management.

Improvements in the marginal physical product of machinery may be possible through evaluation of the installation's production load, degree of centralization, and output requirements with the object of selecting the appropriate hardware to match the workload. Many installations are finding that the new key-to-disk and drum configurations are providing significant throughput increases and error rate reductions. As the capabilities of the on-line mini-computer are expanded through software development to utilize the optional card punches and printers that some manufacturers now offer, this

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equipment may replace much of the background punch-sort-validate-print-return processing that now requires main frame or slave computer time.

Additional gains in productivity can be made by expanding the role of the keypunch operator by encouraging her participation in planning and control functions that have been previously reserved for supervisory and management personnel, by keeping her informed of her performance and how it relates to the goals of the organization, and by employing the motivational techniques that have been discussed. Hardware replacement and the incentive plan are external signs that a new management approach is being taken in keypunch and are obvious factors in increasing the marginal physical product of machinery and labor. But t. se factors are mechanical in their application and required in part for the production information and employee measurements they provide. The internal approach taken to provide job enrichment, to implement meaningful employee counselling, and to accurately employ motivational techniques provides the largest challenge to data processing management, and if successful, will result in the most significant improvements in the keypunch installation.

# SYSTEM FLOWCHART

## 1. Creating the System File
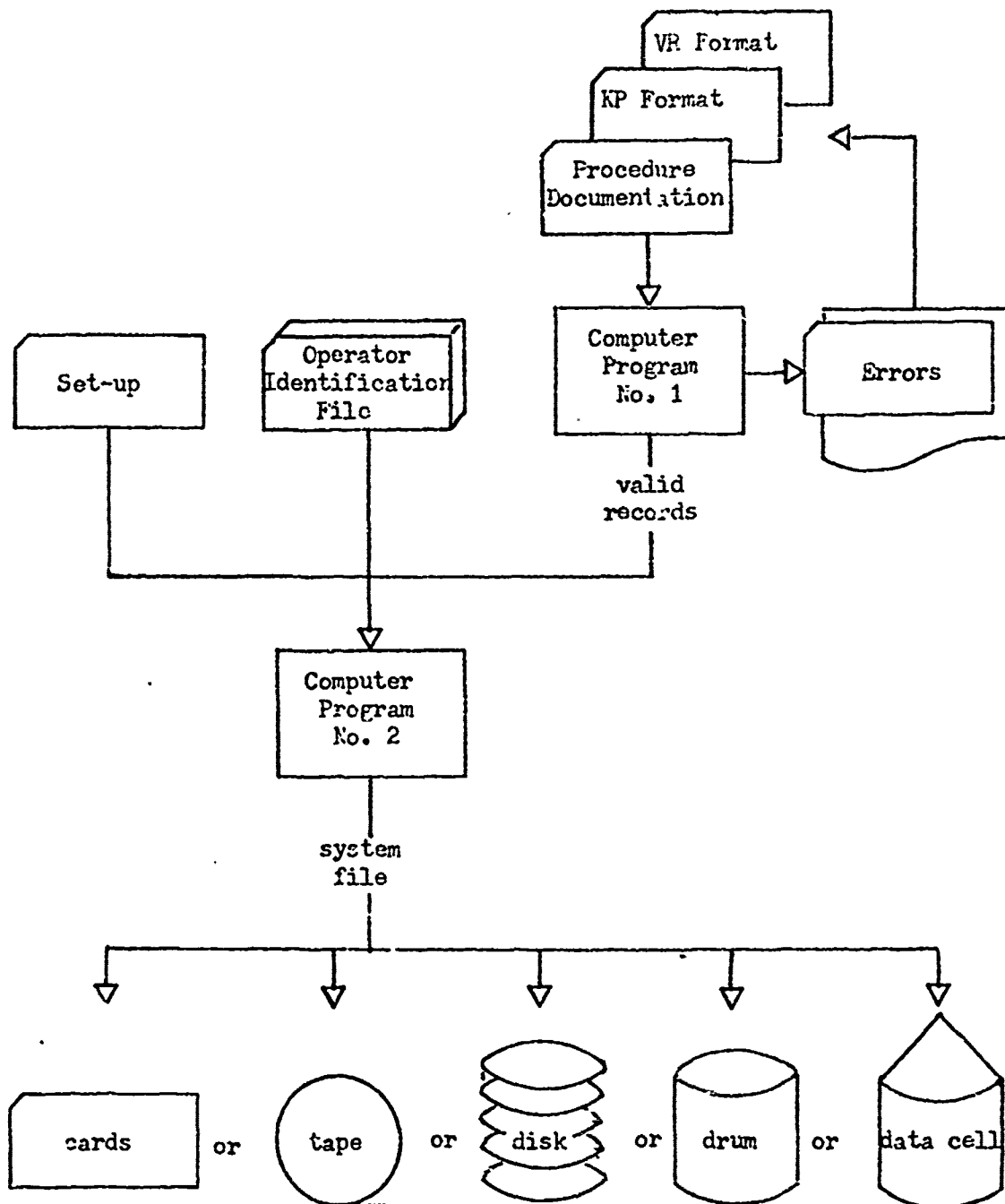
## 2. Updating the System File
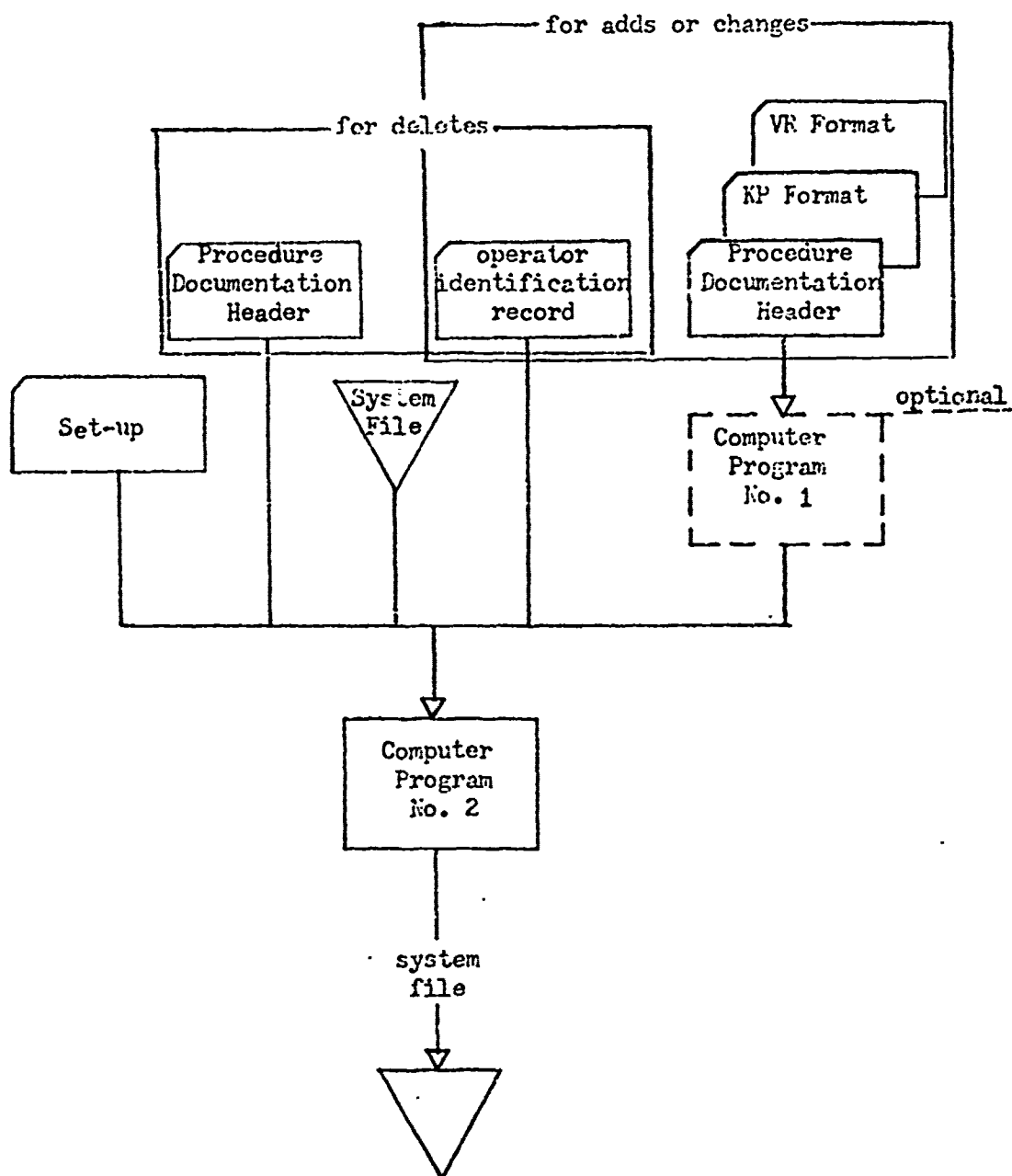
## 3. Incentive Reward Period Processing



Batch Control Form

Supervisor Exception Log

Backlog

optional

System File

Set-up

Computer Program No. 3

optional

Individual Production Report

Shift Production Report

Installation Production Report

MUACS Report
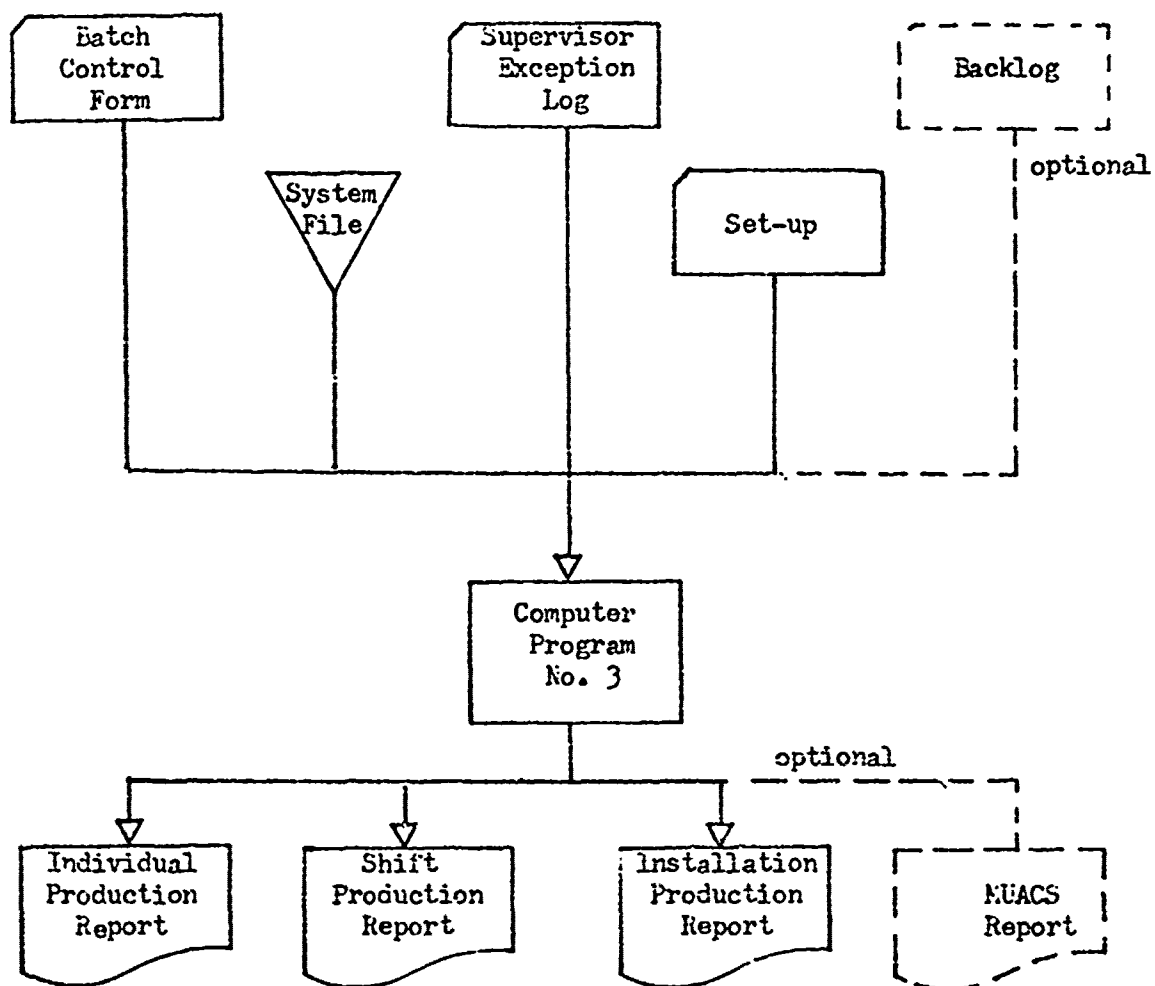
## 4. Adjusting the Procedure Time Model

```
  ┌─────────┐      ┌─────────┐      ┌─────────┐
  \ System  /      │  Batch  │      │ Management│
   \ File  /       │ Control │      │ Override │
    \─────/        │  Form   │      │          │
       │           └─────────┘      └─────────┘
       │                │                │
       └────────────────┼────────────────┘
                        │
                        ▽
                 ┌─────────────┐
                 │  Computer   │
                 │  Program    │
                 │   No. 4     │
                 └─────────────┘
                        │
          ┌─────────────┴──────────────┐
          │                            │
        New                     Procedure Time
       System                    Model Report
        File                           │
          │                  ┌─────────┴─────────┐
          ▽                  │                   │
         ▽▽▽             Procedure            Percent
          ▽              Number               Change
                         Sequence             Sequence
                             │                   │
                             ▽                   ▽
                       ┌──────────┐        ┌──────────┐
                       │  PTM     │        │  PTM     │
                       │ Report   │   ─    │ Report   │
                       └──────────┘        └──────────┘
```
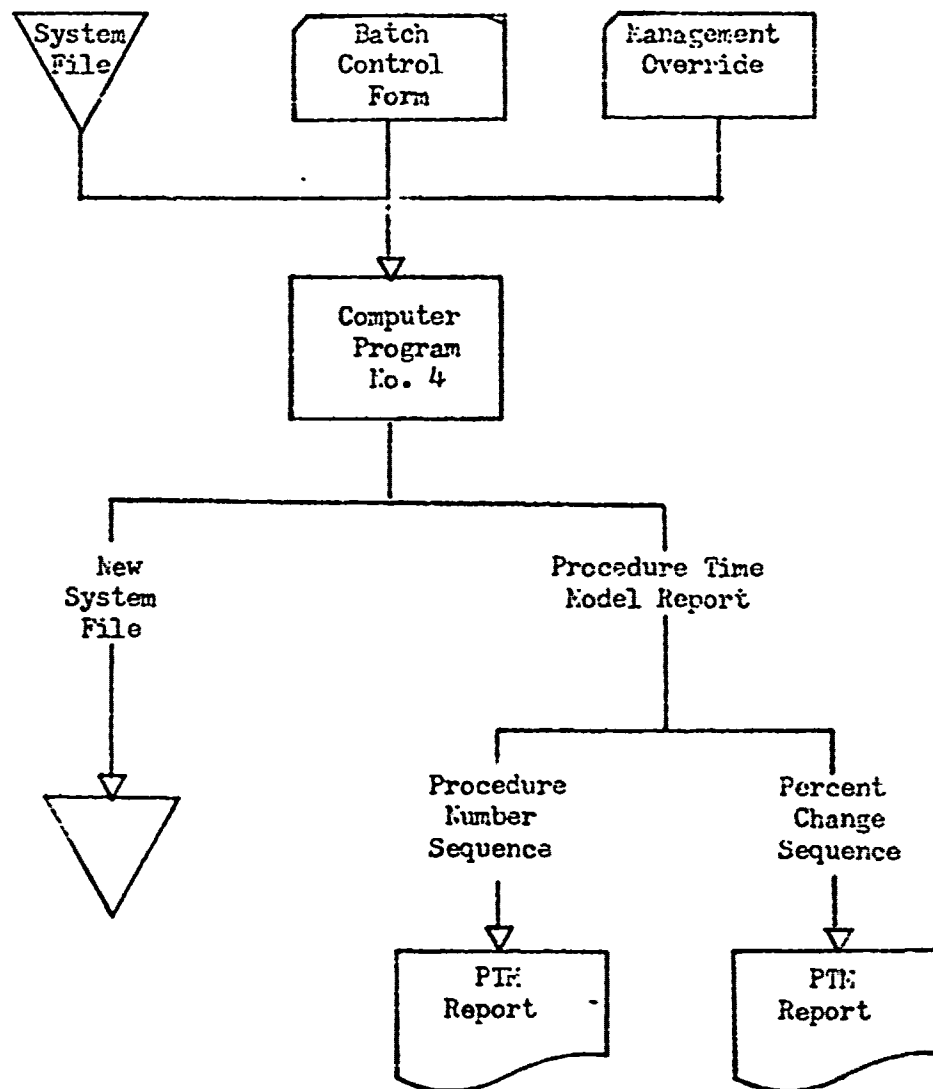
# APPENDIX B

## RECORD FORMATS

1. Set-up Record

| Field | Column | Content |
|---|---|---|
| Document Identifier | 1 - 3 | "ZU1" |
| Month | 4 -17 | Report month and year |
| Work Days | 18-19 | Days in pay period for Program #3 |
| blank | 20-80 | blank |

2. Supervisor Exception Log

| Field | Column | Content |
|---|---|---|
| Document Identifier | 1 - 3 | "ZU2" |
| Date | 4 - 9 | Day-month-year (ddmmyy) |
| Operator Number | 10-12 | Three digit numeric |
| Code | 13-14 | See Table XI |
| Time | 15-17 | Time in hours |
| | 18 | Time in tenths |
| Pay Type | 19-20 | See Table XIII |
| blank | 21-8 | blank |

3. Batch Control Form

| Field | Column | Content |
|---|---|---|
| Document Identifier | 1 - 3 | "ZU3" for regular production "ZU4" for Hotline operations |
| Date | 4 - 9 | Day-month-year (ddmmyy) |
| Procedure Number | 10-15 | Any alphameric |
| Volume | 16-20 | Numeric source document count |

3. Batch Control Form - Continued

| Field | Column | Content |
|---|---|---|
| Operator Number | | |
| Initial Process | | |
| Keypunch | 21-23 | Numeric |
| Verification | 24-26 | Numeric |
| Corrections | | |
| Keypunch | 27-29 | Numeric |
| Verification | 30-32 | Numeric |
| | | |
| Start Time | | |
| Initial Process | | |
| Keypunch | 33-36 | 24-hour time - blank if hotline |
| Verification | 37-40 | 24-hour time - blank if hotline |
| Corrections | | |
| Keypunch | 41-44 | 24-hour time - blank if hotline |
| Verification | 45-48 | 24-hour time - blank if hotline |
| | | |
| Stop Time | | |
| Initial Process | | |
| Keypunch | 49-52 | 24-hour time - blank if hotline |
| Verification | 53-56 | 24-hour time - blank if hotline |
| Corrections | | |
| Keypunch | 57-60 | 24-hour time - blank if hotline |
| Verification | 61-64 | 24-hour time - blank if hotline |
| | | |
| Errors | 65-67 | Numeric - blank if hotline |
| | | |
| Pay Type | | |
| Initial Process | | |
| Keypunch | 68-69 | See Table X discussion |
| Verification | 70-71 | See Table X discussion |
| Corrections | | |
| Keypunch | 72-73 | See Table X discussion |
| Verification | 74-75 | See Table X discussion |
| | | |
| blank | 76-80 | blank |

4. Backlog Input (Optional-for MUACS)

| Field | Column | Content |
|---|---|---|
| Document Identifier | 1 - 3 | "ZU5" |
| Date | 4 - 9 | Day-month-year (ddmmyy) |
| Procedure Number | 10-15 | Any alphameric |
| Code | 17 | Blank or "V" See Table XIV discussion |
| Volume | 18-21 | Numeric source document count |
| blank | 22-80 | blank |

5. **Operator Identification Record**

| Field | Column | Content |
|---|---|---|
| Document Identifier | 1 - 3 | "ZU6" |
| Date | 4 - 9 | Day-month-year (ddmmyy) |
| Operator Number | 10-12 | Three digit numeric |
| blank | 13-16 | blank |
| Change Code | 17 | Add = blank, Delete = "D" Change = "C" |
| Shift | 18 | 1, 2, or 3 |
| Pay Grade | 19-20 | GS grade |
| Pay Step | 21-22 | GS shift |
| Name | 23-42 | Last, first, middle initial |
| blank | 43-80 | blank |

6. **Procedure Documentation**
   a. **Header**

| Field | Column | Content |
|---|---|---|
| Document Identifier | 1 - 3 | "ZU7" |
| Date | 4 - 9 | Day-month-year (ddmmyy) |
| Procedure Number | 10-15 | Any alphameric |
| Suffix | 16 | A, B, ... for multiple outputs. |
| Change Code | 17 | Add = blank, Delete - "D", Change = "C" |
| Size | 18-20 | Number of columns in record |
| Ratings (5) | 21-25 | Excellent = "E", Good = "G", Fair = "F", or Poor = "P" |
| Name | 26-45 | Procedure Name (optional) |
| MUACS Code | 46 | Easy = "E", Normal - blank, Diff = "D" |
| blank | 47-80 | blank |
| MUACS code | 56 | Easy = "E", Normal = blank, Difficult = "D" |
| blank | 57-80 | blank |

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b. **Keypunch Format**

Standard IBM 029 Program Drum Card

c. **Verification Format**

Standard IBM 059 Program Drum Card

7. **Procedure Time Model**

| Field | Column | Content |
|---|---|---|
| Document Identifier | 1 - 3 | "ZU8" for the system file<br>"ZU9" for the management override |
| Date | 4 - 9 | Day-month-year (ddmmyy) |
| Procedure Number | 10-15 | Any alphameric |
| MUACS Code | 16 | Easy = "E", Normal = blank,<br>Diff = "D" |
| Keypunch data | | |
| Strokes | 17-19 | Number of strokes in procedure |
| Predetermined | 20-23 | Predetermined Procedure Time<br>Model |
| Month 3 | 24-27 | Production time three months ago |
| Month 2 | 28-31 | Production time two months ago |
| Month 1 | 32-35 | Production time last month |
| Use Prior | 36-39 | Procedure Time Model used<br>last month |
| Use Current | 40-43 | Procedure Time Model in use |
| Verification data | | |
| Strokes | 44-46 | Number of strokes in procedure |
| Predetermined | 47-50 | Predetermined Procedure Time<br>Model |
| Month 3 | 51-54 | Production time three months ago |
| Month 2 | 55-58 | Production time two months ago |
| Month 1 | 59-62 | Production time last month |
| Use Prior | 63-66 | Procedure Time Model used<br>last month |
| Use Current | 67-70 | Procedure Time Model in use |
| blank | 71-80 | blank |

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COMPUTER PROGRAM NUMBER ONE

PROCEDURE DOCUMENTATION VALIDATION

## CONTENTS

Program Synopsis

Input Description

Output Description

Sample Report Output

COBOL Program

## PROGRAM SYNOPSIS

Program number one validates the procedure documentation records - the header, keypunch format, and verification format. Errors are printed in narrative form by procedure number. The listing is used by the keypunch supervisor to locate error records and make the appropriate corrections before the records are further processed.

## INPUT DESCRIPTION

a. Set-up Record

b. Procedure Documentation Header

c. Keypunch Format

d. Verification Format

## OUTPUT DESCRIPTION

a. Procedure Documentation Error Report

JOB NUMBER     ERROR

001000     TWO HEADERS FOR THE SAME JOB NUMBER BUT NO SUFFIX INDICATED.

002000     CHANGE CODE NOT BLANK, A, OR D.

006000     CHANGE CODE NOT BLANK, A, OR D.
           EXTRA HANDLING NOT E, G, F, OR P.
           MUACS CODE NOT BLANK, E, N, OR D.
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 25. CHARACTER FOUND WAS M
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 21. CHARACTER FOUND WAS H
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 32. CHARACTER FOUND WAS L
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 43. CHARACTER FOUND WAS M
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 55. CHARACTER FOUND WAS R

005000     EXTRA HANDLING NOT E, G, F, OR P.
           MUACS CODE NOT BLANK, E, N, OR D.
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 18. CHARACTER FOUND WAS N
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 32. CHARACTER FOUND WAS V
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 65. CHARACTER FOUND WAS R
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 74. CHARACTER FOUND WAS V

007000     ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 17. CHARACTER FOUND WAS G
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 69. CHARACTER FOUND WAS *
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 70. CHARACTER FOUND WAS *
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 71. CHARACTER FOUND WAS *
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 72. CHARACTER FOUND WAS *

008000     MUACS CODE NOT BLANK, E, N, OR D.
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 92. CHARACTER FOUND WAS B
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 109. CHARACTER FOUND WAS L
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 110. CHARACTER FOUND WAS L
           ILLEGAL CHARACTER FOUND IN RECORD IN COLUMN 111. CHARACTER FOUND WAS L

011000     TWO HEADERS BACK TO BACK.  FORMAT CARD MISSING.

012000     STRAY FORMAT CARD FOUND AFTER SUBJECT PROCEDURE.  CARD IGNORED.

12 JOBS PROCESSED.     8 JOBS INVALID WITH 28 ERRORS.

PROCEDURE DOCUMENTATION VALIDATION REPORT

```
000010   IDENTIFICATION DIVISION.                                         PROG 1
000020   PROGRAM-ID. 'THESIS'.                                            PROG 1
000030   AUTHOR. LCDR DANFORTH.                                           PROG 1
000040   INSTALLATION. NPGS MONTEREY.                                     PROG 1
000050   DATE-WRITTEN.                                                    PROG 1
000060   DATE-COMPILED.                                                   PROG 1
000070   REMARKS.                                                         PROG 1
000080   ENVIRONMENT DIVISION.                                            PROG 1
000090   CONFIGURATION SECTION.                                           PROG 1
000100   SOURCE-COMPUTER. IBM-360-67.                                     PROG 1
000110   OBJECT-COMPUTER. IBM-360-67.                                     PROG 1
000120   INPUT-OUTPUT SECTION.                                            PROG 1
000130   FILE-CONTROL.                                                    PROG 1
000140       SELECT IN-REC ASSIGN TO 'CARDIN' UTILITY.                    PROG 1
000150       SELECT OUTPUT-FILE ASSIGN TO 'PRINT' UTILITY.                PROG 1
000160   DATA DIVISION.                                                   PROG 1
000170   FILE SECTION.                                                    PROG 1
000180   FD  IN-REC LABEL RECORDS ARE OMITTED RECORDING MODE IS F         PROG 1
000190       RECORD CONTAINS 80 CHARACTERS DATA RECORD IS INPUT-REC.      PROG 1
000200   01  INPUT-REC.                                                   PROG 1
000210       02  IDOC-ID               PICTURE XXX.                       PROG 1
000220           88  ISET-UP                         VALUE 'ZU1'.         PROG 1
000230           88  IHEAD                           VALUE 'ZU7'.         PROG 1
000240       02  CDATE                 PICTURE X(14).                     PROG 1
000250       02  IN-REK REDEFINES CDATE.                                  PROG 1
000260           03  IDATE             PICTURE X(6).                      PROG 1
000270           03  KEY-HEAD.                                            PROG 1
000280               04  IPROC-NR      PICTURE X(6).                      PROG 1
000290               04  ISUFFIX       PICTURE X.                         PROG 1
000300           02  IKEY-CODE         PICTURE X.                         PROG 1
000310       02  ISIZE                 PICTURE 999.                       PROG 1
000320       02  IRATINGS              PICTURE X        OCCURS 5 TIMES.   PROG 1
000330       02  FILLER                PICTURE X(20).                     PROG 1
000340       02  IMUACS                PICTURE X.                         PROG 1
000350       02  FILLER                PICTURE X(34).                     PROG 1
000360   FD  OUTPUT-FILE RECORDING MODE IS F LABEL RECORDS ARE OMITTED    PROG 1
000370       RECORD CONTAINS 133 CHARACTERS DATA RECORD IS PRINT-LINE.    PROG 1
000380   01  PRINT-LINE                PICTURE X(133).                    PROG 1
000390   WORKING-STORAGE SECTION.                                         PROG 1
000400       PAGE-NR               PICTURE 99        VALUE 0.             PROG 1
000410   77  C                     PICTURE 9(3)      VALUE 0.             PROG 1
000420   77  JOBS                  PICTURE 9(3)      VALUE 0.             PROG 1
000430   77  LINEZ                 PICTURE 99        VALUE 0.             PROG 1
000440   77  SPASE                 PICTURE X         VALUE SPACES.        PROG 1
000450   77  EPR                   PICTURE 9         VALUE 0.             PROG 1
000460   77  ERRS                  PICTURE 9(3)      VALUE 0.             PROG 1
000470   77  ERRORS                PICTURE 9(3)      VALUE 0.             PROG 1
000480   77  RUNCD                 PICTURE X.                             PROG 1
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000490  77  I              PICTURE X(6)    VALUE SPACES.                        PROG 1
000500  77  J              PICTURE S999    VALUE 0.                             PROG 1
000510  77                 PICTURE 9(3)    VALUE 0.                             PROG 1
000520  01  WORK-SPACE.                                                         PROG 1
000530  01  FORMIN REDEFINES WORK-SPACE  PICTURE X(80)  OCCURS 6 TIMES.         PROG 1
000540      02  FORMAT       PICTURE X    OCCURS 480 TIMES.                     PROG 1
000550  01  OUTPUT-LINES.                                                       PROG 1
000560      02  TOP.                                                            PROG 1
000570          03  FILLER   PICTURE X(43)  VALUE SPACES.                       PROG 1
000580          03           PICTURE X(43)  VALUE 'KEYPUNCH PROCEDURE DO        PROG 1
000590          'CUMENTATION VALIDATION'.                                       PROG 1
000600          03  FILLER   PICTURE X(10)  VALUE SPACES.                       PROG 1
000610          03  H1       PICTURE X(14)  VALUE SPACES.                       PROG 1
000620          03  FILLER   PICTURE X(10)  VALUE SPACES.                       PROG 1
000630          03  TB       PICTURE X(6)                                       PROG 1
000640          03  TC       PICTURE ZZ9   VALUE 'PAGE '.                       PROG 1
000650          03  FILLER   PICTURE X(46)  VALUE SPACES.                       PROG 1
000660      02  HEAD.                                                           PROG 1
000670          03  FILLER   PICTURE X(10)  VALUE SPACES.                       PROG 1
000680          03  HA       PICTURE X(10)  VALUE 'JOB NUMBER'.                 PROG 1
000690          03  FILLER   PICTURE X(5)   VALUE SPACES.                       PROG 1
000700          03  TB       PICTURE X(10)  VALUE 'ERROR'.                      PROG 1
000710      02  DETAIL-LINE.                                                    PROG 1
000720          03  FILLER   PICTURE XXX    VALUE SPACES.                       PROG 1
000730          03  DLA      PICTURE X(6)   VALUE SPACES.                       PROG 1
000740          03  FILLER   PICTURE X(12)  VALUE SPACES.                       PROG 1
000750          03  DLB      PICTURE X(112)                                     PROG 1
000760      02  EOJ-LINE.                                                       PROG 1
000770          03  FILLER   PICTURE X       VALUE SPACES.                      PROG 1
000780          03  ELL1     PICTURE ZZ9                                        PROG 1
000790          03  ELL2     PICTURE X(18)   VALUE ' JOBS PROCESSED.'.          PROG 1
000800          03  ELL3     PICTURE ZZ9                                        PROG 1
000810          03  ELL4     PICTURE X(19)   VALUE ' JOBS INVALID WITH '.       PROG 1
000820          03  ELL5     PICTURE ZZ9                                        PROG 1
000830          03  ELL6     PICTURE X(8)    VALUE ' ERRORS.'.                  PROG 1
000840          03  FILLER   PICTURE X(78)   VALUE SPACES.                      PROG 1
000850  01  ERROR-MSGS.                                                         PROG 1
000860      02  E1   PICTURE X(60)  VALUE 'TWO HEADERS FOR THE S                PROG 1
000870          'AME JOB NUMBER BUT NO SUFFIX INDICATED.'.                      PROG 1
000880      02  E2   PICTURE X(66)  VALUE 'MULTIPLE CARD JOBS BE                PROG 1
000890          'ING PROCESSED SEPARATELY OR SUFFIX NOT BLANK.'.                PROG 1
000900      02  E3   PICTURE X(31)  VALUE 'CHANGE CODE NOT BLANK                PROG 1
000910          ', A, OR D.'.                                                   PROG 1
000920      02  E4   PICTURE X(33)  VALUE 'MUACS CODE NOT BLANK,                PROG 1
000930          ' E, N, OR D.'.                                                 PROG 1
000940      02  E5           PICTURE X(32)  VALUE 'EXTRA HANDLING N             PROG 1
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000970-        'OT E, G, F, OR P'.  PICTURE X(47)  VALUE 'TWO HEADERS BACK TO B
000980-    02  :E6       FORMAT CARD MISSING.'.
000990-    0?  :E7.
0001000-       03  'E71        PICTURE X(41)  VALUE 'ILLEGAL CHARACTER FOU
0001010-           'ND IN RECORD COLUMN '.
0001020-       03  :E72        PICTURE ZZ9.
0001030-       03  :E73        PICTURE X(23)  VALUE '.  CHARACTER FOUND WA
0001040-           'S '.
0001050-       03  :E74        PICTURE X.
0001060-    02  'E8            PICTURE X(63)  VALUE 'STRAY FORMAT CAR
0001070-       'D FOUND AFTER SUBJECT PROCEDURE.  CARD IGNORED.'.
0001080- PROCEDURE DIVISION.
0001090-    OPEN INPUT IN-REC OUTPUT OUTPUT-FILE.
0001100-
0001110- LOOP-A.
0001120-    READ IN-REC AT END GO TO EOJ.
0001130-    IF ISET-UP MOVE CDATE TO HI-i PERFORM NEW-PAGE GO TO LOOP-A.
0001140-    IF IHEAD GO TO HEAD-CHECK.
0001150-    MOVE 8 TO ERR PERFORM PRINT.
0001160-    GO TO LOOP-A.
0001170-
0001180- HEAD-CHECK.
0001190-    IF IPROC-NR NOT = PROC MOVE 'O' TO SPASE ADD 1 TO JOBS.
0001200-    IF IPROC-NR = PROC AND ISUFFIX = ' ' OR = 'A'
0001210-       MOVE 1 TO ERR PERFORM PRINT.  IF IPROC-NR NOT = PROC
0001220-    IF ISUFFIX NOT = ' ' PERFORM PRINT.
0001230-    MOVE 2 TO ERR PERFORM PRINT.
0001240-    MOVE IPROC-NR TO PROC.
0001250-    IF IKEY-CODE = 'A' OR = 'C' OR = 'D' NEXT SENTENCE
0001260-       ELSE MOVE 3 TO ERR PERFORM PRINT.
0001270-    PERFORM RATE-CHECK THRU RC VARYING I FROM 1 BY 1 UNTIL I > 5.
0001280-    IF IMUACS = 'E' OR = 'N' OR = 'D' OR = ' ' NEXT SENTENCE
0001290-       ELSE MOVE 4 TC ERR PERFORM PRINT.
0001300-    MOVE ISIZE TO C.
0001310-    MOVE 'K' TO RUNCD.
0001320-
0001330- LOOP-B.
0001340-    MOVE 1 TO J.
0001350-    PERFORM LOAD-REC VARYING I FROM C BY -80 UNTIL I < 1.
0001360-    IF IHEAD MOVE 6 TO ERR PERFORM PRINT GO TO HEAD-CHECK.
0001370-    MOVE 1 TO I.
0001380-
0001390- LOOP-C.
0001400-    IF I > C GO TO LOOP-D.
0001410-    IF FORMAT (I) = '&' OR = '-' OR = 'O' OR = 'A'
0001420-       OR = '1' OR = '.' OR = '/' OR = 'A' ADD 1 TO I GO TO LOOP-C ELSE MOVE i TO
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001460       E72 MOVE FORMAT (I) TO E74 MOVE 7 TO ERR          PROG 1
001470           PERFORM PRINT ADD 1 TO I GO TO LOOP-C.        PROG 1
001480                                                         PROG 1
001490   LOOP-D.                                               PROG 1
001500       IF RUNCD = 'K' MOVE 'V' TO RUNCD MOVE 1 TO I GO TO LOOP-B.  PROG 1
001510       GO TO LOOP-A.                                     PROG 1
001520                                                         PROG 1
001530   LOAD-REC.                                             PROG 1
001540       READ IN-REC AT END GO TO EOJ.                     PROG 1
001550       IF HEAD MOVE 0 TO I.                              PROG 1
001560       MOVE INPJT-REC TO WORK (J).                       PROG 1
001570       ADD 1 TO J.                                       PROG 1
001580                                                         PROG 1
001590   RATE-CHECK.                                           PROG 1
001600       IF IRATINGS (I) = 'E' OR = 'G' OR = 'F' OR = 'P'  PROG 1
001610       NEXT SENTENCE ELSE MOVE 5 TO ERR PERFORM PRINT.   PROG 1
001620   RC. EXIT.                                             PROG 1
001630                                                         PROG 1
001640   PRINT.                                                PROG 1
001650       IF LINEZ > 54 PERFORM NEW-PAGE.                   PROG 1
001660       IF ERR = 1 MOVE E1 TO DLB.                        PROG 1
001670       IF ERR = 2 MOVE E2 TO DLB.                        PROG 1
001680       IF ERR = 3 MOVE E3 TO DLB.                        PROG 1
001690       IF ERR = 4 MOVE E4 TO DLB.                        PROG 1
001700       IF ERR = 5 MOVE E5 TO DLB.                        PROG 1
001710       IF ERR = 6 MOVE E6 TO DLB.                        PROG 1
001720       IF ERR = 7 MOVE E7 TO DLB.                        PROG 1
001730       IF ERR = 8 MOVE E8 TO DLB.                        PROG 1
001740       IF SPASE = 0. MOVE PROC TO DLA, ADD 1 TO ERRORS   PROG 1
001750       ELSE MOVE SPACES TO DLA.                          PROG 1
001760       WRITE PRINT-LINE FROM DETAIL-LINE AFTER SPASE.    PROG 1
001770       ADD 1 TO ERRS.                                    PROG 1
001780       ADD 1 TO LINEZ.                                   PROG 1
001790       MOVE 1 TO SPASE.                                  PROG 1
001800                                                         PROG 1
001810   NEW-PAGE.                                             PROG 1
001820       MOVE 0 TO LINEZ.                                  PROG 1
001830       ADD 1 TO PAGE-NR.                                 PROG 1
001840       MOVE PAGE-NR TO TC.                               PROG 1
001850       WRITE PRINT-LINE FROM TOP AFTER 0.                PROG 1
001860       WRITE PRINT-LINE FROM HEAD AFTER 2.               PROG 1
001870   EOJ.                                                  PROG 1
001880       MOVE JOBS TO EL1.                                 PROG 1
001890       MOVE ERRORS TO EL3.                               PROG 1
001900       MOVE ERRS TO EL5.                                 PROG 1
001910       WRITE PRINT-LINE FROM EOJ-LINE AFTER 3.           PROG 1
001920       CLOSE IN-REC, OUTPUT-FILE.                        PROG 1
001930       STOP RUN.                                         PROG 1
```

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COMPUTER PROGRAM NUMBER TWO

CREATE AND UPDATE THE SYSTEM FILE

## CONTENTS

Program Synopsis

Input Description

Output Description

COBOL Program

## PROGRAM SYNOPSIS

Program number two processes all additions, changes, and
deletions to the system file which is one file containing
the operator identification records and a documentation
header and time model record for each documented procedure.

## INPUT DESCRIPTION

    a.   Set-up Record

    b.   Operator Identification Record

    c.   Procedure Documentation Header

    d.   Keypunch Format (for adds and changes)

    e.   Verification Format (for adds and changes)

    f.   Current System File

## OUTPUT DESCRIPTION

    a.   New System File

```
000010    IDENTIFICATION DIVISION.
000020    PROGRAM-ID. 'THESIS'.
000030    AUTHOR. LCDR DANFORTH.
000040    INSTALLATION. NPGS MONTEREY.
000050    DATE-WRITTEN.
000060    DATE-COMPILED.
000070    REMARKS.
000080    ENVIRONMENT DIVISION.
000090    CONFIGURATION SECTION.
000100    SOURCE-COMPUTER. IBM-360-67.
000110    OBJECT-COMPUTER. IBM-360-67.
000120    INPUT-OUTPUT SECTION.
000130    FILE-CONTROL.
000140    SELECT IN-REC ASSIGN TO 'CARDIN' UTILITY.
000150    SELECT SYSINP ASSIGN TO 'SYSINP' UTILITY.
000160    SELECT SYSTEM-OUT ASSIGN TO 'SYSOPT' UTILITY.
000170    DATA DIVISION.
000180    FILE SECTION.
000190    FD IN-REC LABEL RECORDS ARE OMITTED RECORDING MODE IS F
000200       RECORD CONTAINS 80 CHARACTERS DATA RECORD IS INPUT-REC.
000210    01 INPUT-REC.
000220       02 IDOC-ID           PICTURE XXX.
000230          88 ISET-UP                            VALUE 'ZU1'.
000240          88 IOP-ID                             VALUE 'ZU6'.
000250          88 IHEAD                              VALUE 'ZU7'.
000260       02 CDATE             PICTURE X(14).
000270       02 IN-REK REDEFINES CDATE.
000280          03 IDATE          PICTURE X(6).
000290          03 IKEY-OP.
000300             04 IOP-NR      PICTURE XXX.
000310             04 FILLER      PICTURE X(4).
000320          03 IKEY-HEAD REDEFINES IKEY-OP.
000330             04 IPROC-NR    PICTURE X(6).
000340             04 ISUFFIX     PICTURE X.
000350          03 IKEY-CODE      PICTURE X.
000360             88 IADD                            VALUE ' '.
000370             88 ICHG                            VALUE 'C'.
000380             88 IDELETE                         VALUE 'D'.
000390       02 ISIZE             PICTURE 999.
000400       02 IRATINGS          PICTURE X(55) OCCURS 5 TIMES.
000410       02 FILLER            PICTURE X(80).
000420    FD SYSINP LABEL RECORDS ARE OMITTED RECORDING MODE IS F
000430       RECORD CONTAINS 80 CHARACTERS DATA RECORD IS SYSINP.
000440    01 SYSTEM-IN            PICTURE X(80).
000450    FD SYSTEM-OUT LABEL RECORDS ARE OMITTED RECORDING MODE IS F
000460       RECORD CONTAINS 80 CHARACTERS DATA RECORD IS SYSOPT.
000470    01 SYSOPT               PICTURE X(80).
000480    WORKING-STORAGE SECTION.
```

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000490 77  KP-TMU-FACTOR                      PICTURE 99         VALUE 5.        PROG 2
000500 77  VR-TMU-FACTOR                      PICTURE 99         VALUE 50.       PROG 2
000510 77  R                                  PICTURE 99         VALUE 00.       PROG 2
000520 77  COL                                PICTURE 999        VALUE 00.       PROG 2
000530 77  K                                  PICTURE S9         VALUE 0.        PROG 2
000540 77  I                                  PICTURE X(4)V9(3)  VALUE 'K'.      PROG 2
000550 77  RUNCD                              PICTURE 9(4)V9(3).                 PROG 2
000560 01  TMU-PTM.                                                             PROG 2
000570 02  FILLER                             PICTURE X(3)       VALUE 'ZU8'.    PROG 2
000580 02  PDATE                              PICTURE X(6).                      PROG 2
000590 02  PPROC-NR                           PICTURE X(6).                      PROG 2
000600 02  FILLER                             PICTURE X          VALUE SPACES.   PROG 2
000610 02  KP-DATA.                                                             PROG 2
000620 03  KP-STROK                           PICTURE 9(3)                       PROG 2
000630 03  KP-TIME                            PICTURE 9(4)       OCCURS 6 TIMES. PROG 2
000640 02  VER-DATA.                                                            PROG 2
000650 03  VR-STROK                           PICTURE 9(3)       OCCURS 6 TIMES. PROG 2
000660 03  VR-TIME                            PICTURE 9(4)                       PROG 2
000670 02  FILLER                             PICTURE X(10)      VALUE SPACES.   PROG 2
000680 01  SDATA-IN.                                                            PROG 2
000690 02  SDOC-ID                            PICTURE XXX.                       PROG 2
000700 88  SOP-ID                                                VALUE 'ZU6';   PROG 2
000710 88  SHEAD                                                 VALUE 'ZU7';   PROG 2
000720 88  SPTM                                                  VALUE 'ZU8'.   PROG 2
000730 88  SYSPAD                             VALUE '999'.                       PROG 2
000740 02  FILLER                             PICTURE X(6).                      PROG 2
000750 02  SKEY-OP.                                                             PROG 2
000760 03  SCP-NR                             PICTURE X(4)  VALUE SPACES.        PROG 2
000770 03  FILLER                             PICTURE XXX   VALUE SPACES.        PROG 2
000780 02  SKEY-HEAD REDEFINES SKEY-OP.                                         PROG 2
000790 03  SPROC-NR                           PICTURE X(6).                      PROG 2
000800 03  FILLER                             PICTURE X(64).                     PROG 2
000810 02  FILLER                                                               PROG 2
000820 01  COUNTERS.                                                            PROG 2
000830 02  TSKIP-DUP                          PICTURE 9(4)       VALUE 0.        PROG 2
000840 02  SKIP                               PICTURE 9(4)       VALUE 0.        PROG 2
000850 02  DUP                                PICTURE 9(4)       VALUE 0.        PROG 2
000860 02  NUM                                PICTURE 9(4)       VALUE 0.        PROG 2
000870 02  ALPHA                              PICTURE 9(4)       VALUE 0.        PROG 2
000880 02  STROKES                            PICTURE 9(4)                       PROG 2
000890 01  WORK-SPACE.                                                          PROG 2
000900 02  WORK                               PICTURE X(80)      OCCURS 6 TIMES. PROG 2
000910 01  FORMIN REDEFINES WORK-SPACE.                                         PROG 2
000920 02  FORMAT                             PICTURE X          OCCURS 480 TIMES. PROG 2
000930                                                                          PROG 2
000940                                                                          PROG 2
```

```
000950      PROCEDURE DIVISION.
000960
000970          OPEN INPUT IN-REC, SYSINP      OUTPUT SYSTEM-OUT.
000980          PERFORM READ-SYSINP.
000990          PERFORM READ-INREC.
001000
001010      LOOP-A.
001020          IF IOP-ID
001030          THEN IF SOP-ID
001040              THEN IF IOP-NR > SOP-NR
001050                  THEN GO TO LOOP-5
001060                  ELSE GO TO LOOP-C
001070              ELSE MOVE '999' TO SOP-NR GO TO LOOP-C
001080          ELSE IF SOP-ID GO TO LOOP-5.
001090
001100      LOOP-B.
001110          IF IHEAD
001120          THEN IF SHEAD
001130              THEN IF IPROC-NR > SPROC-NR
001140                  THEN GO TO LOOP-10
001150                  ELSE GO TO LOOP-C
001160              ELSE MOVE '999999' TO SPROC-NR GO TO LOOP-D
001170          ELSE GO TO LOOP-9.
001180
001190      LOOP-C.
001200          IF IDELETE
001210          THEN IF IOP-NR = SOP-NR
001220              THEN GO TO LOOP-3
001230              ELSE GO TO LOOP-4
001240          ELSE IF IOP-NR = SOP-NR
001250              THEN GO TO LOOP-1
001260              ELSE GO TO LOOP-2.
001270
001280      LOOP-D.
001290          IF IDELETE
001300          THEN IF IPROC-NR = SPROC-NR
001310              THEN GO TO LOOP-8
001320              ELSE GO TO LOOP-9
001330          ELSE IF IPROC-NR = SPROC-NR
001340              THEN GO TO LOOP-6
001350              ELSE GO TO LOOP-7.
001360
001370      LOOP-1.
001380          PERFORM READ-SYSINP.
001390      LOOP-2.
001400          WRITE SYSOPT FROM INPUT-REC.
001410          PERFORM READ-INREC.
001420          GO TO LOOP-A.
```

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0001430           LOOP-3. PERFORM READ-SYSINP.                    PROG 2
0001440                                                           PROG 2
0001450           LOOP-4. PERFORM READ-INREC.                     PROG 2
0001460                                                           PROG 2
0001470               GO TO LOOP-A.                               PROG 2
0001480                                                           PROG 2
0001490                                                           PROG 2
0001500           LOOP-5. WRITE SYSOPT FROM SYSTEM-IN.            PROG 2
0001510               PERFORM READ-SYSINP.                        PROG 2
0001520               GO TO LOOP-A.                               PROG 2
0001530                                                           PROG 2
0001540           LOOP-6. PERFORM READ-SYSINP  2 TIMES.           PROG 2
0001550                                                           PROG 2
0001560           LOOP-7. PERFORM CALC THRU CALC-EXIT.            PROG 2
0001570               GO TO LOOP-A.                               PROG 2
0001580                                                           PROG 2
0001590                                                           PROG 2
0001600           LOOP-8. PERFORM READ-SYSINP  2 TIMES.           PROG 2
0001610                                                           PROG 2
0001620           LOOP-9. PERFORM READ-INREC.                     PROG 2
0001630               GO TO LOOP-A.                               PROG 2
0001640                                                           PROG 2
0001650                                                           PROG 2
0001660           LOOP-10. PERFORM LOOP-11 2 TIMES.               PROG 2
0001670               GO TO LOOP-A.                               PROG 2
0001680                                                           PROG 2
0001690           LOOP-11. WRITE SYSOPT FROM SYSTEM-IN.           PROG 2
0001700               PERFORM READ-SYSINP.                        PROG 2
0001710                                                           PROG 2
0001720                                                           PROG 2
0001730           READ-INREC. PERFORM RI-START THRU RI-EXIT.      PROG 2
0001740           RI-START. READ IN-REC AT END GO TO RI-END.      PROG 2
0001750           RI-EXIT. EXIT.                                  PROG 2
0001760           RI-END. IF SYSPAD GO TO EOJ.                    PROG 2
0001770               READ SYSINP AT END GO TO EOJ.               PROG 2
0001780               WRITE SYSOPT FROM SYSTEM-IN.                PROG 2
0001790               GO TO RI-END.                               PROG 2
0001800                                                           PROG 2
0001810           EOJ. CLOSE IN-REC, SYSINP, SYSTEM-OUT.          PROG 2
0001820               STOP RUN.                                   PROG 2
0001830                                                           PROG 2
0001840           READ-SYSINP. PERFORM RS-START THRU RS-EXIT.     PROG 2
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001910 RS-START.
001920     IF SYSPAD GO TO RS-EXIT ELSE READ SYSINP
001930         AT END MOVE '999' TO SDOC-ID GO TO RS-EXIT.
001940     MOVE SYSTEM-IN TO SDATA-IN.
001950 RS-EXIT. EXIT.
001960
001970
001980 CALC.
001990     MOVE 0 TO KP-DATA, VER-DATA.
002000 LOOP-G.
002010     MOVE 0 TO KP-STROK, KP-TIME (1), KP-TIME (2), KP-TIME (3),
002020         KP-TIME (4), KP-TIME (5), KP-TIME (6),
002030     MOVE 0 TO VR-STROK, VR-TIME (1), VR-TIME (2), VR-TIME (3),
002040         VR-TIME (4), VR-TIME (5), VR-TIME (6).
002050     MOVE SPACES TO WORK-SPACE.
002060     MOVE ZERO TO COUNTERS, TMU, R.
002070     PERFORM LOOP-I THRU I-EXIT VARYING I FROM 1 BY 1
002080         UNTIL I > 5.
002090     MOVE ISIZE TO COL.
002100     MOVE IPROC-NR TO PPROC-NR.
002110     MOVE IDATE TO PDATE.
002120     IF RUNCD NOT = '0' WRITE SYSOPT FROM INPUT-REC.
002130     MOVE 'K' TO RUNCD.
002140 LOOP-H.
002150     MOVE 1 TO K.
002160     PERFORM LOOP-J VARYING I FROM COL BY -80 UNTIL I < 1.
002170     MOVE 1 TO I.
002180 LOOP-K.
002190     IF FORMAT (I) = '-' THEN ADD 1 TO TSKIP-DUP, GO TO LOOP-SKIP.
002200     IF FORMAT (I) = '0' OR FORMAT (I) = '/' THEN ADD 1 TO
002210         TSKIP-DUP, GO TO LOOP-DUP.
002220     IF FORMAT (I) = ',' GO TO LOOP-NUM.
002230     IF FORMAT (I) = '1' GO TO LOOP-ALPHA.
002240     ADD 1 TO I.
002250     GO TO K-EXIT.
002260 LOOP-SKIP.
002270     ADD 1 TO SKIP.
002280     ADD 1 TO I.
002290     IF FORMAT (I) = '&' GO TO LOOP-SKIP ELSE GO TO K-EXIT.
002300 LOOP-DUP.
002310     ADD 1 TO DUP.
002320     ADD 1 TO I.
002330     IF FORMAT (I) = '&' OR FORMAT (I) = 'A' GO TO LOOP-DUP,
002340         ELSE GO TO K-EXIT.
002350 LOOP-NUM.
002360     ADD 1 TO NUM.
002370     ADD 1 TO STROKES.
002380     ADD 1 TO I.
```

```
         IF FORMAT (I) = '8' GO TO LOOP-NUM ELSE GO TO K-EXIT.
     LOOP-ALPHA.
         ADD 1 TO ALPHA.
         ADD 1 TO STROKES
         IF FORMAT (I) = 'A' GO TO LOOP-ALPHA.
         ... I > CO NEXT SENTENCE ELSE GO TO LOOP-K.
         COMPUTE TMU = (NUM + ALPHA * 1.3 + DUP * .3 + SKIP * .04
         + TSKIP-DUP * 1.2) * (1.2 - .04 * R).
     IF RUNCD = 'K'
         COMPUTE TMU = TMU * KP-TMU-FACTOR
         ADD STROKES TO KP-STROK
         MOVE 'V' TO RUNCD
         PERFORM ADD-KP-TMU VARYING I FROM 1 BY 1 UNTIL I > 6
         MOVE SPACES TO FORMIN
         MOVE ZERO TO COUNTERS
         GO TO LOOP-H.
         COMPUTE TMU = TMU + VR-TMU-FACTOR.
         ADD STROKES TO VR-STROK.
         MOVE 'K' TO RUNCD.
         PERFORM ADD-VR-TMU VARYING I FROM 1 BY 1 UNTIL I > 6.
         MOVE PTM TO SYSOPT.
         WRITE SYSOPT.
     LOOP-L.
         PERFORM READ-INREC.
         IF NOT IPROC-NR GO TO CALC-EXIT.
         IF IPROC-NR NOT = PPROC-NR GO TO CALC-EXIT.
         IF ISUFFIX NOT = ' ' MOVE 'Q' TO RUNCD GO TO LOOP-G.
         DISPLAY 'DUPLICATE INPUT'.
         DISPLAY INPUT-REC.
         GO TO LOOP-L.
     CALC-EXIT. EXIT.
     LOOP-I.
         IF IRATINGS (II) = 'E' ADD 1 TO R GO TO I-EXIT.
         IF IRATINGS (II) = 'G' ADD 2 TO R GO TO I-EXIT.
         IF IRATINGS (II) = 'F' ADD 3 TO R GO TO I-EXIT.
         ADD 4 TO R.
     I-EXIT. EXIT.
     LOOP-J.
         PERFORM READ-INREC.
         MOVE INPUT-REC TO WORK (K).
         ADD 1 TO K.
     ADD-KP-TMU.
         ADD TMU TO KP-TIME (I).
```

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```
002870    ADD-VR-TMU.                          PROG 2
002880    ADD TMU TO VR-TIME (1).              PROG 2
002890                                         PROG 2
```

COMPUTER PROGRAM NUMBER THREE

PRODUCTION EFFECTIVENESS AND
INCENTIVE REWARD CALCULATIONS

## CONTENTS

Program Synopsis

Input Description

Output Description

Sample Report Output

COBOL Program

## PROGRAM SYNOPSIS

Program number three processes records of actual production each pay period. The output consists of a report series consisting of data on production efficiency, incentive hours earned, hours of work completed by job order for payroll reporting, and optional MUACS data.

## INPUT DESCRIPTION

- a. Set-up Record
- b. Batch Control Form
- c. Supervisor Exception Log
- d. Backlog Record (optional)
- e. Current System File

## OUTPUT DESCRIPTION

- a. Individual Production Report
- b. Shift Production Report
- c. Installation Production Report
- d. MUACS Report (optional)

PRODUCTION REPORT - INDIVIDUAL

DODSON, GLENDA    OPERATOR NUMBER 012    SHIFT 1    GRADE GS-03 STEP 02    REPORT FOR MARCH 1972

| INCENTIVE TIME AVAILABLE | INCENTIVE TIME ALLOWED | KEYPUNCH ERROR RATE | PRODUCTION EFFICIENCY RATE | INCENTIVE HOURS EARNED | EMPLOYEE UTILIZATION RATE |
|---|---|---|---|---|---|
| 66.0 | 70.3 | 0.0% | 109.0% | 2.6 | 80.0% |

| FUNCTION | JOB ORDER | RG REGULAR | NO NITE DIFF | OT OVER TIME | CE COMP EARN | HP HOL PREM | TOTALS |
|---|---|---|---|---|---|---|---|
| NORMAL PRODUCTION | | | | | | | |
| KP EASY | 622A 00108 | 14.5 | 0.0 | 0.0 | 0.0 | 0.0 | 14.5 |
| KP NORM | 622A 00109 | 38.1 | 0.0 | 0.0 | 0.0 | 0.0 | 38.1 |
| KP DIFF | 622A 00110 | 35.3 | 0.0 | 0.0 | 0.0 | 0.0 | 35.3 |
| VR EASY | 622A 00112 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| VR NORM | 622A 00113 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| VR DIFF | | | | | | | |
| MISCELLANEOUS | | | | | | | |
| CLERICAL | 622A 00110 | 22.9 | 0.0 | 0.0 | 0.0 | 0.0 | 22.9 |
| CORRECTION | 622N 00082 | 12.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.0 |
| TRAINING | 622A 00110 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| OJ TRAIN | 6212 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 |
| TAB ROOM | | | | | | | |
| ABSENT FROM WORK | | | | | | | |
| ANNUAL LV | 620N 00150 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| SICK LV | 620N 00154 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| HOLIDAY LV | 620N 00155 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| ADMIN LV | 620N 00160 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| COMP TKN | | | | | | | |
| HOTLINE OPERATIONS | | | | | | | |
| KEYPUNCH | 622A 00117 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 2.0 |
| VERIFY | 622A 00118 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| REMOTE OPERATIONS | | | | | | | |
| ALL | 621A 00101 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTALS | | 80.0 | 1.0 | 1.0 | 0.0 | 0.0 | 82.0 |

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MUACS REPORT

WORK UNITS:

| | | | COMPLETED | BACKLOGED |
|---|---|---|---|---|
| **NORMAL PRODUCTION** | | | | |
| KP EASY | 622A | 00108 | 2,000 | 100 |
| KP NORM | 622A | 00109 | 4,400 | 200 |
| KP DIFF | 622A | 00110 | 3,500 | 300 |
| VR EASY | 622A | 00111 | 2,000 | 100 |
| VR NORM | 622A | 00112 | 4,400 | 200 |
| VR DIFF | 622A | 00113 | 3,500 | 300 |
| **HOT'INE OPERATIONS** | | | | |
| KEYPUNCH | 622A | 00117 | | |
| VERIFY | 622A | 00118 | | |

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```
000010     IDENTIFICATION DIVISION.
000020     PROGRAM-ID. 'THESIS'.
000030     AUTHOR. LCDR DANFORTH.
000040     INSTALLATION. NPGS MONTEREY.
000050     DATE-WRITTEN.
000060     DATE-COMPILED.
000070     REMARKS.
000080     ENVIRONMENT DIVISION.
000090     CONFIGURATION SECTION.
000100     SOURCE-COMPUTER. IBM-360-67.
000110     OBJECT-COMPUTER. IBM-360-67.
000120     INPUT-OUTPUT SECTION.
000130     FILE-CONTROL.
000140     SELECT IN-REC ASSIGN TO 'CARDIN' UTILITY.
000150     SELECT SYSINP ASSIGN TO 'SYSINP' UTILITY.
000160     SELECT OUT-PUT ASSIGN TO 'PRINTS' UTILITY.
000170     DATA DIVISION.
000180     FILE SECTION.
000190     FD IN-REC LABEL RECORDS ARE OMITTED RECORDING MODE IS F
000200        RECORD CONTAINS 80 CHARACTERS DATA RECORD IS INPUT-REC.
000210     01 INPUT-REC.
000220        02 IDOC-ID              PICTURE XXX.
000230           88 ISET-UP                           VALUE 'ZU1'.
000240           88 IBC                                VALUE 'ZU3'.
000250           88 IHL                                VALUE 'ZU4'.
000260           88 ISU                                VALUE 'ZU2'.
000270           88 IBL                                VALUE 'ZU5'.
000280        02 SET-UP SET-UP.
000290           03 IDATE             PICTURE X(14).
000300           03 IDAYS             PICTURE 99.
000310           03 FILLER            PICTURE X(61).
000320        02 SUP-EXP REDEFINES SET-UP.
000330           03 FILLER            PICTURE X(6).
000340           03 SOP               PICTURE X(3).
000350           03 SCD               PICTURE XX.
000360           03 STIME             PICTURE 999V9.
000370           03 SPTYP             PICTURE XX.
000380           03 FILLER            PICTURE X(60).
000390        02 BATCH-CONTL REDEFINES SET-UP.
000400           03 FILLER            PICTURE X(6).
000410           03 BPROC             PICTURE X(6).
000420           03 BVOL-NR           PICTURE 9(5)  OCCURS 4 TIMES.
000430           03 BTIME             PICTURE 9(4)  OCCURS 8 TIMES.
000440           03 BERR              PICTURE 9(3).
000450           03 BPAYTYP           PICTURE X(2)  OCCURS 4 TIMES.
000460           03 FILLER            PICTURE X(5).
000470        02 BACKLOG REDEFINES SET-UP.
000480
```

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000490  FD  SYSINP
000500      RECORD CONTAINS 80 CHARACTERS
000510      LABEL RECORDS ARE OMITTED RECORDING MODE IS F
000520      SYSTEM-IN DATA RECORD IS SYSTEM-IN.
000530  01  SDOC-ID
000540  02  SDOC-ID
000550      03  FILLER          PICTURE X(6).
000560      03  BLPROC          PICTURE X(6).
000570      03  BLCD            PICTURE X.
000580      03  BLVOL           PICTURE 9(5).
000590      03  FILLER          PICTURE X(59).
000600      88  SOP-ID              PICTURE XXX.
000610      88  SHEAD                           VALUE 'ZU6'.
000620      88  SPTM                            VALUE 'ZU7'.
000630                                          VALUE 'ZU8'.
000640  02  SKEY-OP.
000650      03  SOP-NR          PICTURE X(6).
000660      03  FILLER          PICTURE X(3).
000670      03  SSHIFT          PICTURE X(5).
000680      03  SOP-DATA        PICTURE 9.
000690                          PICTURE X(24).
000700                          PICTURE X(38).
000710  02  SPTMDEL REDEFINES SKEY-OP.
000720      03  FILLER          PICTURE X(6).
000730      03  PMUACS          PICTURE X(6).
000740      03  PSKP            PICTURE 9.
000750      03  FILLER          PICTURE X(20).
000760      03  PUKP            PICTURE 999.
000770      03  PSVR            PICTURE X(20).
000780      03  FILLER          PICTURE 9999.
000790      03  PUVR            PICTURE X(10).
000800  FD  OUT-PUT
000810      LABEL RECORDS ARE OMITTED RECORDING MODE IS F
000820      RECORD CONTAINS 133 CHARACTERS DATA RECORD IS PRINT-LINE.
000830  01  PRINT-LINE          PICTURE X(133).
000840  SD  DETAILS
000850      RECORDING MODE IS F
000860      RECORD CONTAINS 29 CHARACTERS DATA RECORD IS DETAIL-REC.
000870  01  DETAIL-REC.
000880      02  SORT-OP-NR      PICTURE XXX.
000890      02  SORT-KEY        PICTURE X.
000900          88  SOPERTR         VALUE '1'.
000910          88  SEXCEP          VALUE '2'.
000920          88  SMUACBL         VALUE '3'.
000930          88  SMUACMP         VALUE '4'.
000940          88  SERRATE         VALUE '5'.
000950          88  SPROD           VALUE '6'.
          WORKING-STORAGE SECTION.
000920      02  FILLER          PICTURE X(25).
000950      77  FIRST-PASS      PICTURE 9      VALUE 0.
000960      I                   PICTURE 99     VALUE 1.
```

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```
000970 77  ARG-PROC        PICTURE X(6)     VALUE SPACES.
000980 77  ARG-PAY         PICTURE XX.
000990 77  J-PAY           PICTURE 99.
001000 77  ERR-PCNT        PICTURE 999V99.
001010 77  ERR-FAC         PICTURE 999V99.
001020 77  TIME-WORK       PICTURE XXX      VALUE SPACES.
001030 77  OPER-NUM        PICTURE 9999V9   VALUE ZERO.
001040 77  TIME-ALLOWED    PICTURE 999      VALUE ZERO.
001050 77  HOURS-EXCEP     PICTURE 9999V9   VALUE 00.
001060 77  TIME-AVAIL      PICTURE 999V9    VALUE 00.
001070 77  HOURS-AVAIL     PICTURE 9999V9   VALUE 00.
001080 77  PE              PICTURE 999      VALUE 0.000.
001090 77  INCT-HRS        PICTURE 999      VALUE 00.
001100 77  HIGH            PICTURE 999      VALUE 00.
001110 77  LOW             PICTURE 9999V9   VALUE 00.
001120 77  TEST            PICTURE 99       VALUE 00.
001130 77  MID             PICTURE 999      VALUE 0.
001140 77  NS-TIME
001150 77  J
001160 77  K
001170 01  SORT-RECORDS.
001180 02    PROD-REC.
001190 03      FILLER      PICTURE XXX.     VALUE '6'.
001200 03      POP         PICTURE X.
001210 03      FILLER      PICTURE 99.
001220 03      PTIME       PICTURE 999V9.
001230 03      EXCEP-REC.  PICTURE X(17).
001240 03      FILLER
001250 03      FILLER      PICTURE XXX.     VALUE '2'.
001260 03      FILLER      PICTURE X.
001270 03      ETIMEE.     PICTURE 99.
001280 04      EHOUR.      PICTURE 999.
001290 04      EMINS       PICTURE 9.
001300 ETIME  REDEFINES   ETIMEE   PICTURE 999V9.
001310 YS-FLAG             PICTURE X(16).
001320 02    MUACS-BL.
001330 03      FILLER      PICTURE X(4)     VALUE 'BLG3'.
001340 03      FILLER      PICTURE 99.
001350 03      VOL         PICTURE X(5).
001360 03      FILLER      PICTURE X(17).
001370 02    MUACS-CMP.
001380 03      MC-1        PICTURE XXXX     VALUE 'CMP4'.
001390                     PICTURE 99.
```

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001450   03  FILLER              PICTURE X(5).
001460   02  MC-VOL              PICTURE X(17).
001470   03  FILLER.
001480       ERROR-RATE.
001490   03  FILLER              PICTURE XXX.        VALUE '5'.
001500       MC-ROP              PICTURE 9(3).
001510   03  FILLER              PICTURE 9(5).
001520       MC-RVOL             PICTURE X(17).
001530   03  FILLER              PICTURE XXX.        VALUE '1'.
001540   OP-DATA-NR              PICTURE 9.
001550   03  FILLER
001560       OP-SHIFT
001570   04  OODATA.             PICTURE XX.
001580   04  OGRADE              PICTURE X(20).
001590   04  OOSTEP
001600   04  ONAME               OCCURS 50 TIMES.
001610   PTM-TABLE.              PICTURE X(6).
001620   02  PTMENTRY            PICTURE 9(3).
001630   03  XKP-STROK           PICTURE 9(4).
001640   03  XKP-TMU             PICTURE 9(3).
001650   03  VR-STROK            PICTURE 9(4).
001660   03  VR-TMU              PICTURE X.
001670   03  MUACSCD
001680   MUACS-GRID              PICTURE 9(7)        OCCURS 8 TIMES.
001690   02  MUACS-C             PICTURE 9(7)        OCCURS 6 TIMES.
001700   02  MUACS-B
001710   TIME-PEGRID                                 OCCURS 6 TIMES.
001720   02  PEGRID                                  OCCURS 5 TIMES.
001730   02  PE-GRID
001740   MAIN-GRID               PICTURE 999V9
001750   03  MN-GRID.
001760   54  JO-GRID             PICTURE 9(4)V9.     OCCURS 21 TIMES.
001770   05  JO-GRID             PICTURE 9.          OCCURS 6 TIMES.
001780   05  GHOURS              PICTURE 9(7).
001790   05  GFLAGS              PICTURE 9(8).
001800   03  JO-ERR
001810   03  JO-VOL
001820   PRINTER-LINES.
001830   02  HL.
001840   03  FILLER  PICTURE X(20)        VALUE SPACES.
001850   03  A       PICTURE               VALUE 'PRODUCTION REPORT - '.
001860   HL-O  FILLER PICTURE X(32).       VALUE SPACES.
001870   03  B       PICTURE X(42)         VALUE 'REPORT FOR '.
001880   03  HL-1    PICTURE X(11)         VALUE SPACES.
001890   02  L1  FILLER PICTURE X(27)      VALUE SPACES.
001900   03  FILLER PICTURE X              VALUE SPACES.
001910
001920
```

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001930   03  L1-1      PICTURE X(20)  VALUE SPACES.                    PROG
001940   03  C         PICTURE X(25)  VALUE '   OPERATOR NUMBER '.     PROG
001950   03  L1-2      PICTURE X(3)   VALUE SPACES.                    PROG
001960   03  D         PICTURE X(11)  VALUE ' SHIFT '.                 PROG
001970   03  L1-3      PICTURE 9      VALUE 0.                         PROG
001980   03  E         PICTURE X(18)  VALUE '   GRADE GS-'.            PROG
001990   03  L1-4      PICTURE XX     VALUE SPACES.                    PROG
002000   03  F         PICTURE X(7)   VALUE ' STEP '.                  PROG
002010   03  L1-5      PICTURE XX     VALUE SPACES.                    PROG
002020   33  FILLER    PICTURE X(43)  VALUE SPACES.                    PROG
002030   02  L2.                                                       PROG
002040   03  LA,       PICTURE X(80)  VALUE '   INCENTIVE PRODUCTIO IN PROG
002050            CENTIVE KEYPUNCH INCENTIVE                           PROG
002060   03  LB,       PICTURE X(53)  VALUE 'N '.                      PROG
002070            EMPLOYEE                                             PROG
002080   02  L3.                                                       PROG
002090   03  LC,       PICTURE X(80)  VALUE '   TIME      EFFICIENC'.  PROG
002100   03  LD,       PICTURE X(53)  VALUE 'Y '.                      PROG
002110            TIME ERROR   HOURS                                   PROG
002120            UTILIZATION                                          PROG
002130   02  L4.                                                       PROG
002140   03  LE,       PICTURE X(80)  VALUE '   AVAILABLE       A      PROG
002150            LLOWED RATE                                          PROG
002160   03  LF,       PICTURE X(53)  VALUE '   EARNED RATE '.         PROG
002170            RATE                                                 PROG
002180   02  L5.                                                       PROG
002190   03  FILLER    PICTURE X(7)   VALUE SPACES.                    PROG
002200   03  L5-1      PICTURE ZZZ9.9.  VALUE SPACES.                  PROG
002210   03  FILLER    PICTURE X(16)  VALUE SPACES.                    PROG
002220   03  L5-2      PICTURE ZZZ9.9.  VALUE SPACES.                  PROG
002230   03  FILLER    PICTURE X(15)  VALUE SPACES.                    PROG
002240   03  L5-3      PICTURE ZZ9.9.   VALUE '%'.                     PROG
002250   03  FILLER    PICTURE X(17)  VALUE SPACES.                    PROG
002260   03  L5-4      PICTURE ZZ9.9.   VALUE '%'.                     PROG
002270   03  FILLER    PICTURE X(15)  VALUE SPACES.                    PROG
002280   03  L5-5      PICTURE ZZZ9.9.  VALUE SPACES.                  PROG
002290   03  FILLER    PICTURE X(15)  VALUE SPACES.                    PROG
002300   03  L5-6      PICTURE ZZ9.9.   VALUE '%'.                     PROG
002310   03  FILLER    PICTURE X(17)  VALUE SPACES.                    PROG
002320   03  FILLER    PICTURE X(09)  VALUE SPACES.                    PROG
002330   02  L6.                                                       PROG
002340   03  FILLER    PICTURE X(47)  VALUE SPACES.                    PROG
002350   03  G         PICTURE X(63)  VALUE ' RG          ND           PROG
002360            OT          CE           HP'.                        PROG
002370   02  L7.                                                       PROG
002380   03  FILLER    PICTURE X(23)  VALUE SPACES.                    PROG
```

```
002410    03  FILLER PICTURE X(62) VALUE SPACES.
002420    03  H PICTURE X(49) VALUE 'NITE     OVER
002430        'HOL '
002440    02  L8.
002450    03  LG PICTURE X(80) VALUE '           FUNCTION
002460        ' ORDER  REGULAR        DIFF
002470    03  LH PICTURE X(53) VALUE ' E       EARN
002480        ' M       TOTALS  .
002490    02  L9.
002500    03  FILLER PICTURE X(11) VALUE SPACES.
002510    03  L9-1 PICTURE X(10) VALUE SPACES.
002520    03  FILLER PICTURE X(4) VALUE SPACES.
002530    03  L9-2 PICTURE X(11) VALUE SPACES.
002540    03  FILLER PICTURE X(9) VALUE SPACES.
002550    03  L9-3 PICTURE ZZZ9.9.
002560    03  FILLER PICTURE X(9) VALUE SPACES.
002570    03  L9-4 PICTURE ZZZ9.9.
002580    03  FILLER PICTURE X(9) VALUE SPACES.
002590    03  L9-5 PICTURE ZZZ9.9.
002600    03  FILLER PICTURE X(9) VALUE SPACES.
002610    03  L9-6 PICTURE ZZZ9.9.
002620    03  FILLER PICTURE X(9) VALUE SPACES.
002630    03  L9-7 PICTURE ZZZ9.9.
002640    03  FILLER PICTURE X(14) VALUE SPACES.
002650    03  FILLER PICTURE ZZZ9.9.
002660    03  FILLER PICTURE X(2) VALUE SPACES.
002670    02  L10.
002680    03  FILLER PICTURE X(20) VALUE SPACES.
002690    03  L10-1 PICTURE X(112) VALUE SPACES.
002700    03  FILLER PICTURE X VALUE SPACES.
002710    02  M1.
002720    03  FILLER PICTURE X(29) VALUE SPACES.
002730    03  FILLER PICTURE X(12) VALUE 'MUACS REPORT'.
002740    02  M11.
002750    03  FILLER PICTURE X(101) VALUE SPACES.
002760    03  FILLER PICTURE X(41) VALUE SPACES.
002770    03  FILLER PICTURE X(05) VALUE 'WORK UNITS:'.
002780    03  FILLER PICTURE X(9) VALUE SPACES.
002790    03  FILLER PICTURE X(11) VALUE 'COMPLETED'.
002800    03  FILLER PICTURE X(9) VALUE 'BACKLOGED'.
002810    03  FILLER PICTURE X(47) VALUE SPACES.
002820    02  M2.
002830    03  FILLER PICTURE X(20) VALUE SPACES.
002840    03  M2-1 PICTURE X(10) VALUE SPACES.
002850    03  FILLER PICTURE X(15) VALUE SPACES.
002860    03  M2-2 PICTURE VALUE SPACES.
002870
002880
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JOB TIME PRE

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002890  03  FILLER PICTURE X(10) VALUE SPACES.                              PROG 3
002900  03  M2-3 PICTURE ZZ,ZZZ,ZZZ.                                        PROG 3
002910  03  FILLER PICTURE X(10) VALUE SPACES.                              PROG 3
002920  03  M2-4 PICTURE ZZ,ZZZ,ZZZ.                                        PROG 3
002930  03  FILLER PICTURE X(47) VALUE SPACES.                              PROG 3
002940  01  STIME-CON.                                                      PROG 3
002950  02  SHOURS PICTURE 99.                                              PROG 3
002960  02  SMIN PICTURE 99.                                                PROG 3
002970  01  ETIME-CON.                                                      PROG 3
002980  02  EHOURS PICTURE 99.                                              PROG 3
002990  02  EMIN PICTURE 99.                                                PROG 3
003000  01  CON-TIME.                                                       PROG 3
003010  02  CHOURS PICTURE 999.                                             PROG 3
003020  02  CTENTHS PICTURE 9.                                              PROG 3
003030  01  EXPANDED-TIME.                                                  PROG 3
003040  02  EXP-MIN PICTURE 999.                                            PROG 3
003050  02  EXP-TENS PICTURE 99.                                            PROG 3
003060  01  PH-TABLE.                                                       PROG 3
003070  02  PH-ENTRIES.                                                     PROG 3
003080  03  FILLER PICTURE X(20) VALUE 'NORMAL PRODUCTION   '.              PROG 3
003090  03  FILLER PICTURE X(20) VALUE 'MISCELLANEOUS       '.              PROG 3
003100  03  FILLER PICTURE X(20) VALUE 'ABSENT FROM WORK    '.              PROG 3
003110  03  FILLER PICTURE X(20) VALUE 'HOTLINE OPERATIONS  '.              PROG 3
003120  03  FILLER PICTURE X(20) VALUE 'REMOTE OPERATIONS   '.              PROG 3
003130  02  PH-TAB REDEFINES PH-ENTRIES PICTURE X(20) OCCURS 5 TIMES.       PROG 3
003140  01  J-TABLE.                                                        PROG 3
003150  02  J-ENTRIES.                                                      PROG 3
003160  03  FILLER PICTURE X(11) VALUE '622A      00108'.                   PROG 3
003170  03  FILLER PICTURE X(11) VALUE '622A      00109'.                   PROG 3
003180  03  FILLER PICTURE X(11) VALUE '622A      00110'.                   PROG 3
003190  03  FILLER PICTURE X(11) VALUE '622A      00111'.                   PROG 3
003200  03  FILLER PICTURE X(11) VALUE '622A      00112'.                   PROG 3
003210  03  FILLER PICTURE X(11) VALUE '622A      00113'.                   PROG 3
003220  03  FILLER PICTURE X(11) VALUE '622N      00110'.                   PROG 3
003230  03  FILLER PICTURE X(11) VALUE '622N      00820'.                   PROG 3
003240  03  FILLER PICTURE X(11) VALUE '622N      00100'.                   PROG 3
003250  03  FILLER PICTURE X(11) VALUE '622N      00150'.                   PROG 3
003260  03  FILLER PICTURE X(11) VALUE '622N      00151'.                   PROG 3
003270  03  FILLER PICTURE X(11) VALUE '622N      00158'.                   PROG 3
003280  03  FILLER PICTURE X(11) VALUE '622N      00160'.                   PROG 3
003290  03  FILLER PICTURE X(11) VALUE '622A      00117'.                   PROG 3
003300  03  FILLER PICTURE X(11) VALUE '621A      00118'.                   PROG 3
003310  03  FILLER PICTURE X(11) VALUE '621A      00101'.                   PROG 3
003360  02  J-TAB REDEFINES J-ENTRIES PICTURE X(11) OCCURS 20 TIMES.        PROG 3
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003370  01  P-TABLE.
003380      02  P-ENTRIES.
003390          03  FILLER  PICTURE X(10)  VALUE 'KP EASY'.
003400          03  FILLER  PICTURE X(10)  VALUE 'KP NORM'.
003410          03  FILLER  PICTURE X(10)  VALUE 'KP DIFF'.
003420          03  FILLER  PICTURE X(10)  VALUE 'VR EASY'.
003430          03  FILLER  PICTURE X(10)  VALUE 'VR NORM'.
003440          03  FILLER  PICTURE X(10)  VALUE 'VR DIFF'.
003450          03  FILLER  PICTURE X(10)  VALUE 'CLERICAL'.
003460          03  FILLER  PICTURE X(10)  VALUE 'CORRECTION'.
003470          03  FILLER  PICTURE X(10)  VALUE 'TRAINING'.
003480          03  FILLER  PICTURE X(10)  VALUE 'OJ TRAIN'.
003490          03  FILLER  PICTURE X(10)  VALUE 'TAB ROOM'.
003500          03  FILLER  PICTURE X(10)  VALUE 'ANNUAL LV'.
003510          03  FILLER  PICTURE X(10)  VALUE 'SICK LV'.
003520          03  FILLER  PICTURE X(10)  VALUE 'HOLIDAY LV'.
003530          03  FILLER  PICTURE X(10)  VALUE 'ADMIN LV'.
003540          03  FILLER  PICTURE X(10)  VALUE 'COMP TKN'.
003550          03  FILLER  PICTURE X(10)  VALUE 'KEYPUNCH'.
003560          03  FILLER  PICTURE X(10)  VALUE 'VERIFY'.
003570          03  FILLER  PICTURE X(10)  VALUE 'ALL TOTALS'.
003580      02  P-TAB REDEFINES P-ENTRIES PICTURE X(10) OCCURS 20 TIMES.
003590  01  INST-TIMES.
003600      02  SHIFT-BLOCK  OCCURS 4 TIMES.
003610          03  ITAV     PICTURE 999V9.
003620          03  ITAL     PICTURE 999V9.
003630          03  KPERR    PICTURE 999V9.
003640          03  KPCOUNT  PICTURE 999V9.
003650          03  PER      PICTURE 999V9;
003660          03  THE      PICTURE 999V9.
003670          03  EUR      PICTURE 999V9.
003680
003690  PROCEDURE DIVISION.
003700
003710  MAIN-STREAM SECTION.
003720      PERFORM SORT-SECTION.
003730      PERFORM TOTALS-DUMP.
003740      CLOSE OUT-PUT.
003750      STOP RUN.
003760
003770  SORT-SECTION.
003780      SORT DETAILS ON ASCENDING KEY SORT-OP-NR SORT-KEY
003790          INPUT PROCEDURE DUMP-SYSINP
003800          OUTPUT PROCEDURE REPORT-OUTPUT.
003810
003820
003830
003840  DUMP-SYSINP SECTION.
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003850          OPEN INPUT SYSINP, IN-REC.
003860      LOOP-A.
003870          READ SYSINP AT END GO TO INP-CLOSE.
003880          IF SOP-ID THEN
003890          MOVE SOP-NR TO OOP-NR
003900          MOVE SSHIFT TO OSHIFT
003910          MOVE SOP-DATA TO ODATA
003920          MOVE OP-DATA TO DETAIL-REC
003930          RELEASE DETAIL-REC
003940          GO TO LOOP-A.
003950          IF SPTM THEN
003960          ADD 1 TO I
003970          MOVE PPROC TO PROC (I)
003980          MOVE PSKP TO KP-STROK (I)
003990          MOVE PUKP TO KP-TMU (I)
004000          MOVE PSVR TO VR-STROK (I)
004010          MOVE PUVR TO VR-TMU (I)
004020          MOVE PMUACS TO MUACSCD (I).
004030          GO TO LOOP-A.
004040
004050      INP-CLOSE.
004060          CLOSE SYSINP.
004070          MOVE I TO HIGH.
004080          MOVE 'UNK' TO PROC (1).
004090          MOVE 60 TO KP-STROK (1).
004100          MOVE 500 TO VR-STROK (1).
004120          MOVE 500 TO KP-TMU (1).
004130          MOVE 500 TO VR-TMU (1).
004140          MOVE . TO MUACSCD (1).
004150
004160      LOOP-B.
004170          READ IN-REC AT END GO TO DS-EXIT.
004180          IF ISET-UP MOVE IDATE TO HI-1
004190          COMPUTE HOURS-AVAIL = IDAYS * 8.0
004200          GO TO LOOP-B.
004210          IF IBC
004220          IF BOP-NR (1) NOT = SPACES PERFORM IP-KP
004230          IF BOP-NR (2) NOT = SPACES PERFORM IP-VR
004240          IF BOP-NR (3) NOT = SPACES PERFORM CR-KP
004250          IF BOP-NR (4) NOT = SPACES PERFORM CR-VR
004260          GO TO LOOP-B.
004280          IF ISE
004290          IF SOP NOT = SPACES PERFORM EXCEPT THRU EX-EXIT
004300          GO TO LOOP-B.
004310          IF IBL PERFORM BACKLOG GO TO LOOP-B.
004320          GO TO LOOP-B.

            IP-KP.
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004330    MOVE BPROC TO ARG-PROC.                                           PROG 3
004340    PERFORM SEARCH-RTN THRU SR-EXIT.                                  PROG 3
004350    MOVE BOP-NR(1) TO POP, EROP.                                      PROG 3
004360    MOVE BERR TO ERRS.                                                PROG 3
004370    MOVE BVOL TO ERVOL.                                               PROG 3
004380    MOVE ERROR-RATE TO DETAIL-REC.                                    PROG 3
004390    RELEASE DETAIL-REC.                                               PROG 3
004400    IF MUACSCD (I) = 'D' MOVE 3 TO P-I ELSE                           PROG 3
004410    IF MUACSCD (I) = 'E' MOVE 1 TO P-I ELSE MOVE 2 TO P-I.            PROG 3
004420    MOVE P-I TO MC-I.                                                 PROG 3
004430    MOVE BVOL TO MC-VOL.                                              PROG 3
004440    MOVE MUACS-CMP TO DETAIL-REC.                                     PROG 3
004450    RELEASE DETAIL-REC.                                               PROG 3
004460    MOVE BPAYTYP (1) TO ARG-PAY.                                      PROG 3
004470    PERFORM PAY-TYPE THRU PT-EXIT.                                    PROG 3
004480    MOVE J-PAY TO P-J.                                                PROG 3
004490    COMPUTE ERR-PCNT = (BERR / BVOL) * 100.                          PROG 3
004500    IF ERR-PCNT > 2.00                                               PROG 3
004510    THEN COMPUTE ERR-FAC = (-4 + (7 / 3) * ERR-PCNT)                 PROG 3
004520    ELSE MOVE ZERO TO ERR-FAC.                                        PROG 3
004530    COMPUTE TIME-WORK =                                              PROG 3
004540    ((BVOL * ERR-FAC) * KP-TMU (I) / 100000) * 1.15 + .1.           PROG 3
004550    MOVE TIME-WORK TO PTIME.                                          PROG 3
004560    MOVE PROD-REC TO DETAIL-REC.                                      PROG 3
004570    RELEASE DETAIL-REC.                                               PROG 3
004580                                                                      PROG 3
004590 IP-VR. MOVE BPROC TO ARG-PROC.                                       PROG 3
004600    PERFORM SEARCH-RTN THRU SR-EXIT.                                  PROG 3
004610    MOVE BOP-NR (2) TO POP.                                           PROG 3
004620    IF MUACSCD (I) = 'D' MOVE 6 TO P-I ELSE                           PROG 3
004630    IF MUACSCD (I) = 'E' MOVE 4 TO P-I ELSE MOVE 5 TO P-I.            PROG 3
004640    MOVE BPAYTYP (2) TO ARG-PAY.                                      PROG 3
004650    PERFORM PAY-TYPE THRU PT-EXIT.                                    PROG 3
004660    MOVE J-PAY TO P-J.                                                PROG 3
004670    COMPUTE TIME-WORK = BVOL * VR-TMU (I) / 100000.                  PROG 3
004680    MOVE TIME-WORK TO PTIME.                                          PROG 3
004690    MOVE PROD-REC TO DETAIL-REC.                                      PROG 3
004700    RELEASE DETAIL-REC.                                               PROG 3
004710    MOVE P-I TO MC-I.                                                 PROG 3
004720    MOVE BVCL TO MC-VOL.                                              PROG 3
004730    MOVE MUACS-CMP TO DETAIL-REC.                                     PROG 3
004740    RELEASE DETAIL-REC.                                               PROG 3
004750 CR-KP. PERFORM TIME-CONVERSION THRU TC-EXIT.                         PROG 3
004760    MOVE BOP-NR (3) TO EOP.                                           PROG 3
004770    MOVE 8 TO E-I.                                                    PROG 3
004780    MOVE BPAYTYP (3) TO ARG-PAY.                                      PROG 3
004790    PERFORM PAY-TYPE THRU PT-EXIT.                                    PROG 3
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004810        MOVE J-PAY TO E-J.
004820        MOVE EXCEP-REC TO DETAIL-REC.
004830 CR-VR. RELEASE DETAIL-REC.
004840        MOVE BOP-NR (4) TO EOP.
004850        MOVE 8 TO E-I.
004860        MOVE BPAYTYP (4) TO ARG-PAY.
004870        PERFORM PAY-TYPE THRU PT-EXIT.
004880        MOVE J-PAY TO E-J.
004890        MOVE CON-TIME TO ETIME.
004900        MOVE EXCEP-REC TO DETAIL-REC.
004910        RELEASE DETAIL-REC.
004920
004930 EXCEPT.
004940        MOVE SOP TO EOP.
004950        MOVE STIME TO ETIME.
004960        MOVE   TO NS-FLAG.
004970        IF SCD = 'CL' MOVE 7 TO E-I GO TO EX-LOOP.
004980        IF SCD = 'TF' MOVE 9 TO E-I GO TO EX-LOOP.
004990        IF SCD = 'TJ' MOVE 10 TO E-I GO TO EX-LOOP.
005000        IF SCD = 'TB' MOVE 11 TO E-I GO TO EX-LOOP.
005010        IF SCD = 'LA' MOVE 12 TO E-I GO TO EX-LOOP.
005020        IF SCD = 'LS' MOVE 13 TO E-I GO TO EX-LOOP.
005030        IF SCD = 'LH' MOVE 14 TO E-I GO TO EX-LOOP.
005040        IF SCD = 'LE' MOVE 15 TO E-I GO TO EX-LOOP.
005050        IF SCD = 'CT' MOVE 16 TO E-I GO TO EX-LOOP.
005060        IF SCD = 'HK' MOVE 17 TO E-I GO TO EX-LOOP.
005070        IF SCD = 'HV' MOVE 18 TO E-I GO TO EX-LOOP.
005080        IF SCD = 'RM' MOVE 19 TO E-I GO TO EX-LOOP.
005090        IF SCD =      MOVE 21 TO E-I.
005100        IF SPTYP = 'NS' MOVE '*' TO NS-FLAG.
005110 EX-LOOP. MOVE SPTYP TO ARG-PAY.
005120        PERFORM PAY-TYPE THRU PT-EXIT.
005130        MOVE J-PAY TO E-J.
005140        MOVE EXCEP-REC TO DETAIL-REC.
005150 EX-EXIT. RELEASE DETAIL-REC.
005160        EXIT.
005170 BACKLOG. MOVE BLPROC TO ARG-PROC.
005180        PERFORM SEARCH-RTN THRU SR-EXIT.
005220        IF MUACSD (I) = 'D' MOVE 3 TO M-I ELSE MOVE 2 TO M-I.
005230        IF MUACSD (I) = 'E' MOVE 4 TO M-I ELSE MOVE 2 TO M-I.
005250        MOVE BLVOL TO M-VOL.
005260        IF BLCD = 'V' ADD 3 TO M-I.
005280        MOVE MUACS-BL TO DETAIL-REC.
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005290         RELEASE DETAIL-REC.
005300     SEARCH-RTN.
005310         MOVE 2 TO LOW.
005320         IF ARG-PROC < PROC (LOW) OR > PROC (HIGH) MOVE 1 TO I
005330            GO TO SR-EXIT.
005340         IF ARG-PROC = PROC (LOW) MOVE LOW TO I GO TO SR-EXIT.
005350         IF ARG-PROC = PROC (HIGH) MOVE HIGH TO I GO TO SR-EXIT.
005360     S-LOOP.
005370         SUBTRACT LOW FROM HIGH GIVING TEST.
005380         IF TEST = 1 MOVE 1 TO I GO TO SR-EXIT.
005390         COMPUTE MID = (LOW + HIGH) / 2.
005400         IF ARG-PROC = PROC (MID) MOVE MID TO I GO TO SR-EXIT.
005410         IF ARG-PROC < PROC (MID) MOVE MID TO HIGH ELSE MOVE MID
005420            TO LOW.
005430         GO TO S-LOOP.
005440     SR-EXIT. EXIT.
005450
005470     PAY-TYPE.
005480         IF ARG-PAY = ' '  MOVE 1 TO J-PAY GO TO PT-EXIT.
005490         IF ARG-PAY = 'ND' MOVE 2 TO J-PAY GO TO PT-EXIT.
005500         IF ARG-PAY = 'NS' MOVE 2 TO J-PAY GO TO PT-EXIT.
005510         IF ARG-PAY = 'OT' MOVE 3 TO J-PAY GO TO PT-EXIT.
005520         IF ARG-PAY = 'CE' MOVE 4 TO J-PAY GO TO PT-EXIT.
005530         IF ARG-PAY = 'HP' MOVE 5 TO J-PAY GO TO PT-EXIT.
005540         MOVE 1 TO J-PAY.
005550     PT-EXIT. EXIT.
005560
005570     TIME-CONVERSION.
005580         MOVE BTIME (3) TO STIME-CON.
005590         MOVE BTIME (7) TO ETIME-CON.
005600         MOVE 1 TO FIRST-PASS.
005610     TC-LOOP.
005620         IF EHOURS < SHOURS ADD 24 TO EHOURS.
005630         SUBTRACT SHOURS FROM EHOURS GIVING CHOURS.
005640         MOVE EMIN TO EXP-MIN.
005650         IF EMIN < SMIN ADD 60 TO EXP-MIN SUBTRACT 1 FROM CHOURS.
005660         COMPUTE EXP-TENS ROUNDED = (EXP-MIN - SMIN) / 6.
005670         IF EXP-TENS = 10 ADD 1 TO CHOURS MOVE ZERO TO EXP-TENS.
005680         MOVE EXP-TENS TO CTENTHS.
005690         IF FIRST-PASS = 0 GO TO TC-EXIT.
005700         MOVE CON-TIME TO ETIMEE.
005710         MOVE 0 TO FIRST-PASS.
005720         MOVE BTIME (4) TO STIME-CON.
005730         MOVE BTIME (8) TO ETIME-CON.
005740         GO TO TC-LOOP.
005750     TC-EXIT. EXIT.
005760     DS-EXIT. EXIT.
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0005770   MOVE 1 TO FIRST-PASS.
0005780   CLOSE IN-REC.
0005790
0005800   REPORT-OUTPUT SECTION.
0005810   OPEN OUTPUT OUT-PUT.
0005820   PERFORM HOUSEKEEPING.
0005830   MOVE ZERO TO SHIFT-BLOCK (1), SHIFT-BLOCK (2),
0005840     SHIFT-BLOCK (3), SHIFT-BLOCK (4).
0005850   PERFORM ZERO-MC VARYING I FROM 1 BY 1 UNTIL I > 8.
0005860   PERFORM ZERO-MB VARYING I FROM 1 BY 1 UNTIL I > 6.
0005870
0005880   RETURN-LOOP.
0005890   RETURN DETAILS    AT END GO TO REPORT-EXIT.
0005900   RL.
0005910
0005920   IF SMUACMP
0005930   MOVE DETAIL-REC TO MUACS-BL
0005940   ADD M-VOL TO MUACS-C (M-I).
0005950   GO TO RETURN-LOOP.
0005960   IF SMUACBL
0005970   MOVE DETAIL-REC TO MUACS-BL
0005980   ADD M-VOL TO MUACS-B (M-I)
0005990   GO TO RETURN-LOOP.
0006000   DUMP-RETURN.
0006010   IF SORT-OP-NR NOT = OPER-NUM THEN
0006020   IF FIRST-PASS = 1 MOVE ZERO TO FIRST-PASS
0006030   MOVE SORT-OP-NR TO OPER-NUM ELSE GO TO DUMP.
0006040   IF SPROD
0006050   MOVE DETAIL-REC TO PROD-REC
0006060   ADD PTIME TO PE-GRID (P-I, P-J)
0006070   ADD PTIME TO TIME-ALLOWED
0006080   GO TO RETURN-LOOP.
0036100   IF SEXCEP
0006110   MOVE DETAIL-REC TO EXCEP-REC
0006120   ADD ETIME TO GHOURS (E-I, E-J)
0006130   IF E-J = 1 OR E-J = 2 ADD ETIME TO HOURS-EXCEP
0006140   IF NS-LAG = '*' ADD ETIME TO TIME-AVAIL
0006150   GO TO RETURN-LOOP.
0006160   IF SEPRATE
0006170   MOVE DETAIL-REC TO ERROR-RATE
0036180   ADD ERRS TO JO-ERR
0036190   ADD ERVOL TO JO-VOL
0006200   GO TO RETURN-LOOP.
0036210   IF SOPERTR
0006220   MOVE DETAIL-REC TO OP-DATA
0006230   GO TO RETURN-LOOP.
0006240   GO TO RETURN-LOOP.
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006250  DUMP.
006260       MOVE 'INDIVIDUAL' TO H1-O.
006270       WRITE PRINT-LINE FROM H1 AFTER 0.
006280       MOVE OOP-NR TO L1-2.
006290       MOVE OSHIFT TO L1-3.
006300       MOVE OGRADE TO L1-4.
006310       MOVE OOSTEP TO L1-5.
006320       MOVE ONAME TO L1-1.
006330       WRITE PRINT-LINE FROM L1 AFTER 3.
006340       WRITE PRINT-LINE FROM L2 AFTER 3.
006350       WRITE PRINT-LINE FROM L3 AFTER 1.
006360       WRITE PRINT-LINE FROM L4 AFTER 1.
006370       IF HOURS-EXCEP > HOURS-AVAIL
006380          THEN MOVE ZERO TO TIME-AVAIL
006390          ELSE COMPUTE TIME-AVAIL =
006400               TIME-AVAIL + HOURS-AVAIL - HOURS-EXCEP
006410       MOVE TIME-AVAIL TO L5-1.
006420       ADD TIME-AVAIL TO ITAV (CSHIFT).
006430       MCVE TIME-ALLOWED TO ITAL (OSHIFT).
006440       ADD TIME-ALLOWED TO L5-2.
006450       IF JO-VOL = 0 MOVE 3 TO ERR-PCNT GO TO D1.
006460       COMPUTE ERR-PCNT ROUNDED = (JO-ERR / JO-VOL) * 100.
006470  D1.
006480       MOVE ERR-PCNT TO L5-3.
006490       ADD ERR-PCNT TO KPERR (OSHIFT).
006500       ADD 1 TO KPCOUNT (OSHIFT).
006510       IF TIME-AVAIL = 0 MOVE 0 TO PE GO TO D2.
006520       COMPUTE PE ROUNDED = (TIME-ALLOWED / TIME-AVAIL) * 100.
006530  D2.
006540       MOVE PE TO L5-4.
006550       ADD PE TO PER (OSHIFT).
006560       IF PE V 100 MOVE 0 TO INCT-HRS GO TO D21.
006570       COMPUTE INCT-HRS ROUNDED = TIME-AVAIL * ((PE - 100) / 200).
006580  D21.
006590       MOVE INCT-HRS TO L5-5.
006600       ADD INCT-HRS TO IHE (OSHIFT).
006610       IF HOURS-AVAIL = 0 MOVE 0 TO PE GO TO D3.
006620       COMPUTE PE ROUNDED = (TIME-AVAIL / HOURS-AVAIL) * 100.
006630  D3.
006640       MOVE PE TO L5-6.
006650       ADD PE TO EUR (OSHIFT).
006660       WRITE PRINT-LINE FROM L5 AFTER 2.
006670       WRITE PRINT-LINE FROM L6 AFTER 3.
006680       WRITE PRINT-LINE FROM L7 AFTER 1.
006690       WRITE PRINT-LINE FROM L8 AFTER 1.
006700       PERFORM DUMP-GRID THRU DG-EXIT VARYING I FROM 1 BY 1
006710          UNTIL I > 20.
006720       MCVE SORT-OP-NR TO OPER-NUM.
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006730        PERFORM HOUSEKEEPING.
006740        GO TO RL.
006750 HOUSEKEEPING.
006760        MOVE ZERO TO TIME-ALLOWED, HOURS-EXCEP,
006770            JO-ERR, JO-VOL, TIME-AVAIL.
006780        PERFORM ZERO-TABLE THRU ZT-EXIT.
006790
006800 DUMP-GRID.
006810        PERFORM XFER-A VARYING I FROM 1 BY 1 UNTIL I > 6.
006820        PERFORM BALANCE VARYING J FROM 1 BY 1 UNTIL J > 5.
006830        COMPUTE GHOURS (7, 1) =
006840            GHOURS (7, 1) + (HOURS-AVAIL - GHOURS (20, 1)).
006850        MOVE HOURS-AVAIL TO GHOURS (20, 1).
006860        PERFORM CROSS-TOTAL VARYING I FROM 1 BY 1 UNTIL I > 20.
006870        MOVE SPACES TO PRINT-LINE.
006880        WRITE PRINT-LINE AFTER 1.
006890        MOVE 1 TO J, K.
006900        PERFORM PRINT-GRID VARYING I FROM 1 BY 1 UNTIL I > 20.
006910 DG-EXIT. EXIT.
006920
006930 XFER-A.
006940        PERFORM XFER-B THRU XB VARYING J FROM 1 BY 1 UNTIL J > 5.
006950 XFER-B.
006960        IF PE = 0 MOVE 0 TO GHOURS (I, J) ELSE COMPUTE GHOURS (I, J)
006970            ROUNDED = PE-GRID (I, J) * (100.0 / PE).
006980 XB. EXIT.
006990
007000 BALANCE.
007010 BAL-COL. PERFORM BAL-COL VARYING I FROM 1 BY 1 UNTIL I > 19.
007020        ADD GHOURS (I, J) TO GHOURS (20, J).
007030
007040 ZERO-BAL.
007050        COMPUTE GHOURS (7, J) ROUNDED =
007060            GHOURS (20, J) - GHOURS (21, J).
007070 CROSS-TOTAL. PERFORM CROSTOT VARYING J FROM 1 BY 1 UNTIL J > 5.
007080 CROSTOT. ADD GHOURS (I, J) TO GHOURS (I, 6).
007090 PRINT-GRID.
007100        IF GFLAGS (I) = 1 PERFORM PRINT-HEAD.
007110        IF I = 23 MOVE SPACES TO L10-1
007120        WRITE PRINT-LINE FROM L10 AFTER 1.
007130        MOVE P-TAB (I) TO L9-1.
007140        MOVE J-TAB (I) TO L9-2.
007150        MOVE GHOURS (I, 1) TO L9-3.
007160        MOVE GHOURS (I, 2) TO L9-4.
007170        MOVE GHOURS (I, 3) TO L9-5.
007180        MOVE GHOURS (I, 4) TO L9-6.
007190        MOVE GHOURS (I, 5) TO L9-7.
007200        MOVE GHOURS (I, 6) TO L9-8.
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0007210        WRITE PRINT-LINE FROM L9 AFTER 1.
0007220    PRINT-HEAD.
0007230        MOVE PH-TAB (K) TO L10-1.
0007240        WRITE PRINT-LINE FROM L10 AFTER 1.
0007250        ADD 1 TO K.
0007260    ZERO-TABLE.
0007270        PERFORM ZPGRID VARYING I FROM 1 BY 1 UNTIL I > 6.
0007280        PERFORM ZJGRID VARYING I FROM 1 BY 1 UNTIL I > 21.
0007290    ZT-EXIT. EXIT.
0007300    ZERO-MC. MOVE ZERO TO MUACS-C (I).
0007310    ZERO-MB. MOVE ZERO TO MUACS-B (I).
0007320    ZPGRID.
0007330        PERFORM ZP-GRID VARYING J FROM 1 BY 1 UNTIL J > 5.
0007340    ZP-GRID. MOVE ZERO TO PE-GRID (I, J).
0007350    ZJGRID.
0007360        IF I = 1 OR 7 OR 12 OR 17 OR 19 MOVE 1 TO GFLAGS (I)
0007370        ELSE MOVE 0 TO GFLAGS (I).
0007380        PERFORM ZJ-GRID VARYING J FROM 1 BY 1 UNTIL J > 6.
0007390    ZJ-GRID. MOVE ZERO TO JO-GRID (I, J).
0007400    REPORT-EXIT. EXIT.
0007410    TOTALS-DUMP SECTION.
0007420        WRITE PRINT-LINE FROM M1 AFTER 0.
0007430        WRITE PRINT-LINE FROM M11 AFTER 3.
0007440        MOVE PH-TAB (2) TO L10-1.
0007450        WRITE PRINT-LINE L10 AFTER 3.
0007460        PERFORM M-DUMP VARYING I FROM 1 BY 1 UNTIL I > 6.
0007470        MOVE PH-TAB (4) TO L10-1.
0007480        WRITE PRINT-LINE FROM L10 AFTER 3.
0007490        MOVE PH-TAB (17) TO M2-1.
0007500        MOVE J-TAB (17) TO M2-2.
0007510        MOVE MUACS-C (7) TO M2-3.
0007520        MOVE 0 TO M2-4.
0007530        WRITE PRINT-LINE FROM M2 AFTER 2.
0007540        MOVE PH-TAB (18) TO M2-1.
0007550        MOVE J-TAB (18) TO M2-2.
0007560        MOVE MUACS-C (8) TO M2-3.
0007570        WRITE PRINT-LINE FROM M2 AFTER 2.
0007580        GO TO NEXT-REPORT.
0007590    M-DUMP.
0007600        MOVE P-TAB (I) TO M2-1.
0007610        MOVE J-TAB (I) TO M2-2.
0007620        MOVE MUACS-C (I) TO M2-3.
0007630        MOVE MUACS-B (I) TO M2-4.
0007640        WRITE PRINT-LINE FROM M2 AFTER 2.
0007650    NEXT-REPORT.
0007660        MOVE 'INSTALLATION' TO H1-O.
0007670        WRITE PRINT-LINE FROM H1 AFTER 0.
0007680
```

```
0007690        WRITE PRINT-LINE FROM L2 AFTER 3.
0007700        WRITE PRINT-LINE FROM L3 AFTER 1.
0007710        WRITE PRINT-LINE FROM L4 AFTER 1.
0007720        MOVE 'FIRST SHIFT' TO A.
0007730        MOVE SPACES TO B, H1-0, H1-1.
0007740        WRITE PRINT-LINE FROM H1 AFTER 3.
0007750        MOVE 1 TO I.
0007760        PERFORM DUP-INST THRU DI-EXIT.
0007770        MOVE 'SECOND SHIFT' TO A.
0007780        WRITE PRINT-LINE FROM H1 AFTER 3.
0007790        MOVE 2 TO I.
0007800        PERFORM DUP-INST THRU DI-EXIT.
0007810        MOVE 'THIRD SHIFT' TO A.
0007820        WRITE PRINT-LINE FROM H1 AFTER 3.
0007830        MOVE 3 TO I.
0007840        PERFORM DUP-INST THRU DI-EXIT.
0007850        MOVE 'INSTALLATION' TO A.
0007860        WRITE PRINT-LINE FROM H1 AFTER 3.
0007870        MOVE 4 TO I.
0007880    DUP-INST. MOVE SPACES TO H1-0.
0007890        MOVE ITAV (I) TO L5-1.
0007900        MOVE ITAL (I) TO L5-2.
0007910        IF KPCOUNT (I) = 0 MOVE 0 TO ERR-PCNT GO TO DI-A.
0007920        COMPUTE ERR-PCNT ROUNDED = KPERR (I) / KPCOUNT (I).
0007930    DI-A.
0007940        MOVE ERR-PCNT TO L5-3.
0007950        IF KPCOUNT (I) = 0 MOVE 0 TO PE GO TO DI-B.
0007960        COMPUTE PE ROUNDED = PER (I) / KPCOUNT (I).
0007970    DI-B.
0007980        MOVE PE TO L5-4.
0007990        MOVE IHE (I) TO L5-5.
0008000        IF KPCOUNT (I) = 0 MOVE 0 TO PE GO TO DI-C.
0008010        COMPUTE PE ROUNDED = EUR (I) / KPCOUNT (I).
0008020    DI-C.
0008030        MOVE PE TO L5-6.
0008040        WRITE PRINT-LINE FROM L5 AFTER 2.
0008050        IF I = J GO TO DI-EXIT.
0008060        ADD CORRESPONDING SHIFT-BLOCK (I) TO SHIFT-BLOCK (4).
0008070
0008080    DI-EXIT. EXIT.
```

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┌─────────────────────────────────────────────┐
│                                               │
│   COMPUTER PROGRAM NUMBER FOUR                │
│                                               │
│                                               │
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                    ┌──────────────────────────────────────┐
                    │                                        │
                    │  UPDATING THE PROCEDURE TIME MODEL     │
                    │                                        │
                    └──────────────────────────────────────┘
```

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Program Synopsis

Input Description

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Sample Report Output

COBOL Program

PROGRAM SYNOPSIS

Program number four updates the Procedure Time Model
based on reported production and management override records.

INPUT DESCRIPTION

   a.  Batch Control Form

   b.  Management Override

   c.  Current System File

OUTPUT DESCRIPTION

   a.  New System File

   b.  Procedure Time Model Repcrt

KEYPUNCH PROCEDURE REPORT

JANUARY 1972

| JOB-NR | M | PROCEDURE NAME | DATE | SIZE | -RATINGS- | STROK | DATA ENTRY PRED 3-MO | 2-MO | 1-MO | USE1 | USE2 | STROK | VERIFICATION PRED 3-MO | 2-MO | 1-MO | USE1 | USE2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 001000 | F | JOB NR. 1000 | 15 12 72 | 60 | G G E E F | 70 | 500 510 | 520 | 500 | 490 | 500 | 60 | 400 410 | 425 | 390 | 400 | 400 |
| 002000 |   | JOB NR. 2000 | 15 12 72 | 60 | G G E E F | 80 | 600 610 | 620 | 600 | 580 | 600 | 50 | 500 510 | 520 | 490 | 500 | 500 |
| 003300 | E | JOB NR. 3300 | 15 12 72 | 60 | G G E E F | 70 | 500 510 | 520 | 500 | 490 | 500 | 60 | 400 410 | 425 | 390 | 400 | 400 |
| 005000 | E | JOB NR. 5000 | 15 12 72 | 80 | G E F P G | 70 | 500 520 | 500 | 500 | 500 | 420 | 60 | 400 425 | 390 | 400 | 400 | 336* |
| 006000 |   | JOB NR. 6000 | 15 12 72 | 60 | G G E E F | 80 | 600 620 | 600 | 333 | 600 | 459 | 50 | 500 520 | 490 | 278 | 500 | 381* |
| 007000 | D | JOB NR. 7000 | 15 12 72 | 75 | P P P P F | 65 | 700 720 | 700 | 306 | 700 | 521 | 60 | 600 590 | 620 | 263 | 600 | 446* |
| 007001 |   | JOB NR. 7001 | 15 12 72 | 60 | G G E E F | 80 | 600 610 | 620 | 600 | 580 | 600 | 50 | 500 510 | 520 | 490 | 500 | 500 |
| 008000 | D | JOB NR. 8000 | 15 12 72 | 120 | P P F G E | 100 | 900 900 | 900 | 900 | 890 | 900 | 95 | 850 850 | 850 | 850 | 850 | 850 |
| 008300 | E | JOB NR. 8300 | 15 12 72 | 60 | G G E E F | 70 | 500 510 | 520 | 500 | 490 | 500 | 60 | 400 410 | 425 | 390 | 400 | 400 |
| 009000 |   | JOB NR. 9000 | 15 12 72 | 60 | G G E E F | 80 | 600 610 | 620 | 500 | 580 | 600 | 50 | 500 510 | 520 | 490 | 500 | 500 |

```
000010  IDENTIFICATION DIVISION.
000020  PROGRAM-ID. 'THESIS'.
000030  AUTHOR. LCDR DANFORTH.
000040  INSTALLATION. NPGS MONTEREY.
000050  DATE-WRITTEN.
000060  DATE-COMPILED.
000070  REMARKS.
000080  ENVIRONMENT DIVISION.
000090  CONFIGURATION SECTION.
000100  SOURCE-COMPUTER. IBM-360-67.
000110  OBJECT-COMPUTER. IBM-360-67.
000120  INPUT-OUTPUT SECTION.
000130  FILE-CONTROL.
000140      SELECT IN-REC ASSIGN TO 'CARDIN' UTILITY.
000150      SELECT SYSINP ASSIGN TO 'SYSINP' UTILITY.
000160      SELECT SYSTEM-OUT ASSIGN TO 'SYSOPT' UTILITY.
000170      SELECT OUT-PUT ASSIGN TO 'PRINTS' UTILITY.
000180  DATA DIVISION.
000190  FILE SECTION.
000200  FD IN-REC LABEL RECORDS ARE OMITTED RECORDING MODE IS F
000210     RECORD CONTAINS 80 CHARACTERS DATA RECORD IS INPUT-REC.
000220  01 INPUT-REC.
000230     02 IDOC-ID        PICTURE XXX.
000240        88 I SET-UP       VALUE 'ZU1'.
000250        88 IBC            VALUE 'ZU3'.
000260        88 IMO            VALUE 'ZU9'.
000270     02 SET-UP.
000280        03 IDATE       PICTURE X(14).
000290        03 IDAYS       PICTURE 99.
000300        03 FILLER      PICTURE X(61).
000310     02 BATCH-CONTL REDEFINES SET-UP.
000320        03 FILLER      PICTURE X(6).
000330        03 BVOL-NR     PICTURE X(6).
000340        03 BPROC       PICTURE 9(5).
000350        03 BOP-NR      PICTURE X(3).   OCCURS 4 TIMES.
000360        03 BTIME       PICTURE X(4).   OCCURS 8 TIMES.
000370        03 BERR        PICTURE 9(3).
000380        03 BPAYTYP     PICTURE 9(2).   OCCURS 4 TIMES.
000390        03 FILLER      PICTURE X(5).
000400  FD SYSINP LABEL RECORDS ARE OMITTED RECORDING MODE IS F
000410     SYSTEM-IN CONTAINS 80 CHARACTERS DATA RECORD IS SYSTEM-IN.
000420  01 SDOC-ID           PICTURE XXX.
000430        88 SHEAD          VALUE 'ZU7'.
000440        88 SPTM           VALUE 'ZU8'.
000450     02 SHEADER-ID.
000460        03 SHEA
000470        03 HDATE       PICTURE 9(6).
000480        03 FILLER      PICTURE X(18).
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000490     02  SHEADER.
000500         03  HSIZE      PICTURE 9(3).
000510         03  TRATE      PICTURE X(20).
000520         03  HNAME      PICTURE X(35).
000530     02  SPTMODEL REDEFINES SHEADER.
000540         03  PDATE      PICTURE X(6).
000550         03  PPROCS     PICTURE X(6).
000560         03  NUACS      PICTURE X.
000570         03  PSKP       PICTURE 999.
000580         03  PRE-KP     PICTURE X(4).
000590         03  FILLER     PICTURE 9999.
000600         03  MO-3-KP    PICTURE X(4).
000610         03  FILLER     PICTURE 9999.
000620         03  MO-2-KP    PICTURE X(4).
000630         03  FILLER     PICTURE 9999.
000640         03  US-KP      PICTURE X(4).
000650         03  PSVR       PICTURE 9999.
000660         03  PRE-VR     PICTURE X(4).
000670         03  FILLER     PICTURE 9999.
000680         03  MO-3-VR    PICTURE X(4).
000690         03  FILLER     PICTURE 9999.
000700         03  MO-2-VR    PICTURE X(4).
000710         03  FILLER     PICTURE 9999.
000720         03  US-VR      PICTURE X(4).
000730         03  FILLER     PICTURE X(4).
000740         03  FILLER     PICTURE X(10).
000750 FD  SYSTEM-OUT  LABEL RECORDS ARE OMITTED  RECORDING MODE IS F
000760     RECORD CONTAINS 80 CHARACTERS  DATA RECORD IS SYSOPT.
000770 01  SYSOPT                     PICTURE X(80).
000780 FD  OUT-PUT  LABEL RECORDS ARE OMITTED  RECORDING MODE IS F
000790     RECORD CONTAINS 133 CHARACTERS  DATA RECORD IS PRINT-LINE.
000800 01  PRINT-LINE                 PICTURE X(133).
000810 WORKING-STORAGE SECTION.
000820 77  FIRST-PASS     PICTURE 9(7)  VALUE ZERO.
000830 77  VOL            PICTURE X(6)  VALUE ZERO.
000840 77  XPROC          PICTURE X(6)  VALUE SPACES.
000850 77  PAD            PICTURE 9     VALUE '999999'.
000860 01  LINEZ          PICTURE 99    VALUE ZERO.
000870 01  STIME-CON.
000880     02  SHOURS     PICTURE 99.
000890     02  SMIN       PICTURE 99.
000900 01  ETIME-CON.
000910     02  EHOURS     PICTURE 99.
000920     02  EMIN       PICTURE 99.
000930 01  RESULT-TIME.
000940     02  CON-TIME.
000950         03  HOURS      PICTURE 999.
               03  TENTHS     PICTURE 9.
000960     02  RTIME REDEFINES CON-TIME PICTURE 999V9.
           02  RTIM1      PICTURE 999V9  VALUE 0.
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000970   02  RTIM2                   PICTURE 999V9  VALUE 0.      PROG  4
000980 01  EXPANDED-TIME.                                          PROG  4
000990   02  EXP-MIN               PICTURE 999.                    PROG  4
001000 01  EXP-TENS                PICTURE 99.                     PROG  4
001010     NEW-PTM.                                                PROG  4
001020   02  FILLER                PICTURE XXX    VALUE 'ZU8'.     PROG  4
001030   02  PDATE                 PICTURE X(6).                   PROG  4
001040   02  PPROC                 PICTURE X(6).                   PROG  4
001050   02  FMUAS                 PICTURE X.     VALUE SPACES.    PROG  4
001060   02  KP-TIME-A.                                            PROG  4
001070   03  PSKP                  PICTURE 999.                    PROG  4
001080   03  PRE-KP                PICTURE 9999.                   PROG  4
001090   03  MO-3-KP               PICTURE 9999.                   PROG  4
001100   03  MO-2-KP               PICTURE 9999.                   PROG  4
001110   03  MO-1-KP               PICTURE 9999.                   PROG  4
001120   03  US-KP                 PICTURE 9999.                   PROG  4
001130   03  VR-KP                 PICTURE 9999.                   PROG  4
001140   02  KP-TIME-B REDEFINES KP-TIME-A.                        PROG  4
001150   03  FILLER                PICTURE X(3).                   PROG  4
001160   03  VPTMU                 PICTURE 9999   OCCURS 6 TIMES.  PROG  4
001170   02  VR-TIME-A.                                            PROG  4
001180   03  PSVR                  PICTURE 999.                    PROG  4
001190   03  PRE-VR                PICTURE 9999.                   PROG  4
001200   03  MO-3-VR               PICTURE 9999.                   PROG  4
001210   03  MO-2-VR               PICTURE 9999.                   PROG  4
001220   03  MO-1-VR               PICTURE 9999.                   PROG  4
001230   03  US-VR                 PICTURE 9999.                   PROG  4
001240   03  VR-VR                 PICTURE 9999.                   PROG  4
001250   02  VR-TIME-B REDEFINES VR-TIME-A.                        PROG  4
001260   03  FILLER                PICTURE XXX.                    PROG  4
001270   03  VRTMU                 PICTURE 9999   OCCURS 6 TIMES.  PROG  4
001280   02  FILLER                PICTURE X(10)  VALUE SPACES.    PROG  4
001290 01  RPT-LINES.                                              PROG  4
001300   02  H1.                                                   PROG  4
001310   03  FILLER  PICTURE X(75) VALUE ' KEYPUNCH PROCEDURE REPO PROG  4
001320-  'RT'.                                                     PROG  4
001330       H1-1    PICTURE X(58) VALUE SPACES.                   PROG  4
001340   02  H3.                                                   PROG  4
001350   03  FILLER  PICTURE X(75) VALUE ' JOB-NR  M PROCEDURE NA  PROG  4
001360-  'ME *DATE* SIZE -RATINGS- STROK PRED 3-MO 2-           PROG  4
001370   03  FILLER PICTURE X(58) VALUE '-MO 1-MO USE1 USE2 STR   PROG  4
001380-  'OK PRED 3-MO 2-MO 1-MO USE1 USE2 '.                     PROG  4
001390   02  H2.                                                   PROG  4
001400   03  FILLER PICTURE X(58) VALUE SPACES.                   PROG  4
001410   03  FILLER PICTURE X(75) VALUE '*                        PROG  4
001420-  'R Y ----* VERIFICATION  D A T A  E N T                  PROG  4
001430   02  L1.                                                   PROG  4
001440   03  FILLER         PICTURE X    VALUE SPACES.             PROG  4
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001450   03  L1-1     PICTURE X(6).        VALUE SPACES.
001460   003 FILLER   PICTURE XX.          VALUE SPACES.
001470   003 L1-2     PICTURE X.
001480   003 FILLER   PICTURE X(20).       VALUE SPACES.
001490   003 L1-3     PICTURE 99399B99.
001500   003 FILLER   PICTURE XXX.         VALUE SPACES.
001510   003 L1-4     PICTURE ZZZ9.
001520   003 FILLER   PICTURE XXX OCCURS 5 TIMES.  VALUE SPACES.
001530   003 L1-5     PICTURE ZZZ9.        VALUE SPACES.
001540   003 FILLER   PICTURE XX           VALUE SPACES.
001550   003 L1-6     PICTURE ZZZ9.
001560   003 FILLER   PICTURE XXX          VALUE SPACES.
001570   003 L1-7     PICTURE ZZZ9.
001580   003 FILLER   PICTURE XX           VALUE SPACES.
001590   003 L1-8     PICTURE ZZZ9.
001600   003 FILLER   PICTURE XX           VALUE SPACES.
001610   003 L1-9     PICTURE ZZZ9.
001620   003 FILLER   PICTURE XXX          VALUE SPACES.
001630   003 L1-10    PICTURE ZZZ9.
001640   003 FILLER   PICTURE XXX          VALUE SPACES.
001650   003 L1-11    PICTURE ZZZ9.
001660   003 FILLER   PICTURE XX           VALUE SPACES.
001670   003 L1-12    PICTURE ZZ7.9.
001680   003 FILLER   PICTURE XXX          VALUE SPACES.
001690   003 L1-13    PICTURE ZZZ9.
001700   003 FILLER   PICTURE XX           VALUE SPACES.
001710   003 L1-14    PICTURE ZZZ9.
001720   003 FILLER   PICTURE XX           VALUE SPACES.
001730   003 L1-15    PICTURE ZZZ9.
001740   003 FILLER   PICTURE XX           VALUE SPACES.
001750   003 L1-16    PICTURE ZZ7.9.
001760   003 FILLER   PICTURE XX           VALUE SPACES.
001770   003 L1-17    PICTURE ZZZ9.
001780   003 FILLER   PICTURE XX           VALUE SPACES.
001790   003 L1-18    PICTURE ZZZ9.
001800   003 FILLER   PICTURE XX           VALUE SPACES.
001810   003 L1-19    PICTURE ZZZ9.
001820   003 L1-20    PICTURE ZZZ9.
001830   003 FLAG     PICTURE X            VALUE SPACES.
001840
001850   PROCEDURE DIVISION.
001860      OPEN INPUT IN-REC, SYSINP, OUTPUT SYSTEM-OUT, OUT-PUT.
001870   LOOP-A.
001880
001890      IF XPROC NOT = PAD READ IN-REC AT END MOVE PAD TO XPROC
001900         GO TO LOOP-C.
001910      IF ISET-UP MOVE IDATE TO H1-1 PERFORM HEADNG GO TO LOOP-A.
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001930              IF NOT IBC GO TO LOOP-A.                               PROG 4
001940              IF FIRST-PASS = 0 MOVE 5 TO FIRST-PASS GO TO LOOP-B.   PROG 4
001950              GO TO MATCH-IT.                                        PROG 4
001960                                                                     PROG 4
001970          LOOP-B.                                                    PROG 4
001980              READ SYSINP AT END GO TO EOJ.                          PROG 4
001990              IF SHEAD MOVE HNAME TO L1-3 MOVE HDATE TO L1-4 MOVE HSIZE PROG 4
002000                  PERFORM RATE-SHIFT VARYING I FROM 1 BY 1           PROG 4
002010                  UNTIL I > 5.                                       PROG 4
002020              IF NOT SPTM WRITE SYSOPT FROM SYSTEM-IN GO TO LOOP-B.  PROG 4
002030              GO TO MATCH-IT.                                        PROG 4
002040          RATE-SHIFT. MOVE HRATE (I) TO L1-6 (I).                    PROG 4
002050                                                                     PROG 4
002060          MATCH-IT.                                                  PROG 4
002070              IF XPROC = PAD                                         PROG 4
002080                  MOVE SYSTEM-IN TO NEW-PTM GO TO LOOP-C.            PROG 4
002090              IF BPROC < PPROC IN SPTMODEL GO TO LOOP-A.             PROG 4
002100              IF BPROC > PPROC IN SPTMODEL                           PROG 4
002110                  MOVE SYSTEM-IN TO NEW-PTM GO TO LOOP-C.            PROG 4
002120              MOVE CORRESPONDING SPTMODEL TO NEW-PTM.                PROG 4
002130              MOVE CORRESPONDING SPTMODEL TO KP-TIME-A.              PROG 4
002140              MOVE CORRESPONDING SPTMODEL TO VR-TIME-A.              PROG 4
002150                                                                     PROG 4
002160          LOOP-D.                                                    PROG 4
002170              PERFORM TIME-CONVERSION THRU TC-EXIT.                  PROG 4
002180              ADD BVOL TO VOL.                                       PROG 4
002190          DLOOP.                                                     PROG 4
002200              IF XPROC NOT = PAD READ IN-REC AT END MOVE PAD TO XPROC PROG 4
002210              GO TO LOOP-E.                                          PROG 4
002220              IF NOT IBC GO TO DLOOP.                                PROG 4
002230              IF BPROC = PPROC IN NEW-PTM GO TO LOOP-D.              PROG 4
002240                                                                     PROG 4
002250          LOOP-E.                                                    PROG 4
002260              COMPUTE 40-1-KP ROUNDED = (RTIM1 * 1000000) / VOL.     PROG 4
002270              COMPUTE MO-1-VR ROUNDED = (RTIM2 * 1000030) / VOL.     PROG 4
002280              COMPUTE CR-KP ROUNDED = (2 * KPTMU (1) + KPTMU (2)     PROG 4
002290                  + KPTMU (3) + KPTMU (4)) / 6.                      PROG 4
002300              COMPUTE CR-VR ROUNDED = (2 * VRTMU (1) + VRTMU (2)     PROG 4
002310                  + VRTMU (3) + VRTMU (4)) / 6.                      PROG 4
002320              MOVE '*' TO FLAG.                                      PROG 4
002330                                                                     PROG 4
002340          LOOP-C.                                                    PROG 4
002350              WRITE SYSOPT FROM NEW-PTM.                             PROG 4
002360              MOVE PMUACS IN NEW-PTM TO L1-1.                        PROG 4
002370              MOVE PMUACS IN NEW-PTM TO L1-2.                        PROG 4
002380              MOVE PSKP IN NEW-PTM TO L1-7.                          PROG 4
002390              MOVE PSVR IN NEW-PTM TO L1-14.                         PROG 4
002400              MOVE KPTMU (1) TO L1-8.                                PROG 4
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002410      MOVE KPTMU (2) TO LI-9.
002420      MOVE KPTMU (3) TO LI-10.
002430      MOVE KPTMU (4) TO LI-11.
002440      MOVE KPTMU (5) TO LI-12.
002450      MOVE KPTMU (6) TO LI-13.
002460      MOVE VRTMU (1) TO LI-15.
002470      MOVE VRTMU (2) TO LI-16.
002480      MOVE VRTMU (3) TO LI-17.
002490      MOVE VRTMU (4) TO LI-18.
002500      MOVE VRTMU (5) TO LI-19.
002510      MOVE VRTMU (6) TO LI-20.
002520      WRITE PRINT-LINE FROM LI AFTER 2.
002530      ADD 2 TO LINEZ.
002540      IF LINEZ > 54 PERFORM HEADNG.
002550      MOVE SPACES TO FLAG.
002560      MOVE O TO RTIM1, RTIM2.
002570      GO TO LOOP-B.
002580
002590  HEADNG.
002600      MOVE O TO LINEZ.
002610      WRITE PRINT-LINE FROM H1 AFTER O.
002620      WRITE PRINT-LINE FROM H2 AFTER 2.
002630      WRITE PRINT-LINE FROM H3 AFTER 1.
002640
002650  TIME-CONVERSION.
002660      MOVE BTIME (1) TO STIME-CON.
002670      MOVE BTIME (5) TO ETIME-CON.
002680      MOVE 1 TO FIRST-PASS.
002690  TC-LOOP.
002700      IF EHOURS < SHOURS ADD 24 TO EHOURS.
002710      SUBTRACT SHOURS FROM EHOURS GIVING CHOURS.
002720      MOVE EMIN TO EXP-MIN.
002730      IF EMIN < SMIN ADD 60 TO EXP-MIN SUBTRACT 1 FROM CHOURS.
002740      COMPUTE EXP-TENS ROUNDED = (EXP-MIN - SMIN) / 6.
002750      IF EXP-TENS = 10 ADD 1 TO CHOURS MOVE ZERO TO EXP-TENS.
002760      MOVE EXP-TENS TO CTENTHS.
002770      IF FIRST-PASS = 2 GO TO TC-EXIT.
002780      ADD RTIME TO RTIM1.
002790      MOVE 2 TO FIRST-PASS.
002800      MOVE BTIME (2) TO STIME-CON.
002810      MOVE BTIME (6) TO ETIME-CON.
002820      GO TO TC-LOOP.
002830  TC-EXIT.
002840      ADD RTIME TO RTIM2.
002850
002860  EOJ.  CLOSE IN-REC, SYSINP, SYSTEM-OUT, OUT-PUT.
002870      STOP RUN.
002880
```

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